MECHANICAL ENGINEERING

March 1957

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DEPARTMENTS
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SINCE 1888 ALCO Has Said:

"Steam Supply by B&W"

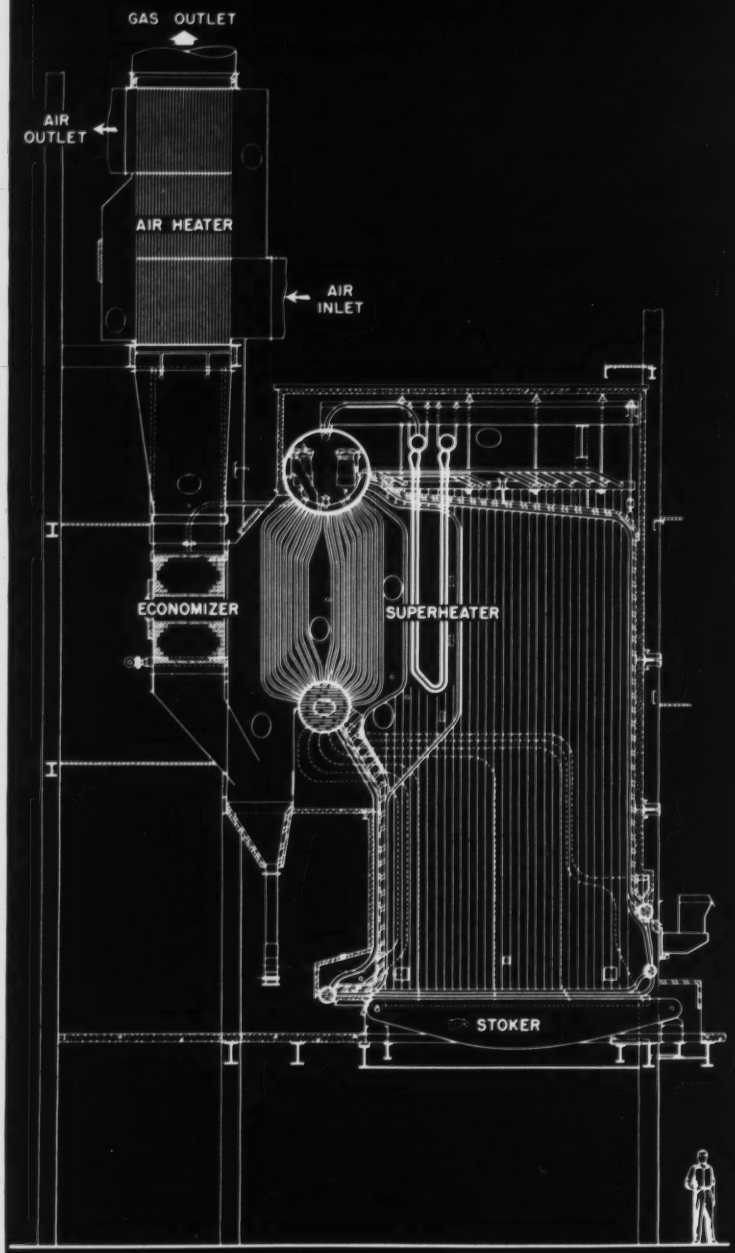
Back in 1888, when the *American Type* locomotive was setting speed records on passenger runs, B&W sold its first boiler to Schenectady Locomotive Works, predecessor of ALCO Products, Inc., to serve the plant.

In January 1955, two more B&W Two-Drum Stirling Boilers went on the line at the company's Schenectady plant. They are providing 100,000 lb of steam per hour for heating, for driving plant auxiliaries, and for some power generation. They bring the number to 40 B&W boilers in ALCO and its predecessors' plants.

What's Interesting about these two latest B&W boilers at ALCO is that they have operated at higher efficiencies than the design contract specified. To ALCO, with its long experience with B&W boilers, this was no surprise.

Long Range, Sustained economy—the product of the top level engineering design found in every B&W boiler—has become something to be expected by long time B&W customers.

More and more manufacturers, in the widest variety of lines, have learned, over the years, to depend upon B&W for an efficient, dependable source of steam. Whatever your steam needs may be—for heating, processing, or power generation—B&W engineers are ready to give you counsel, with nearly a century of steam generation experience behind them. The Babcock & Wilcox Company, Boiler Division, Dept. ME-2, 161 East 42nd St., New York 17, N. Y.



BABCOCK & WILCOX

B&W

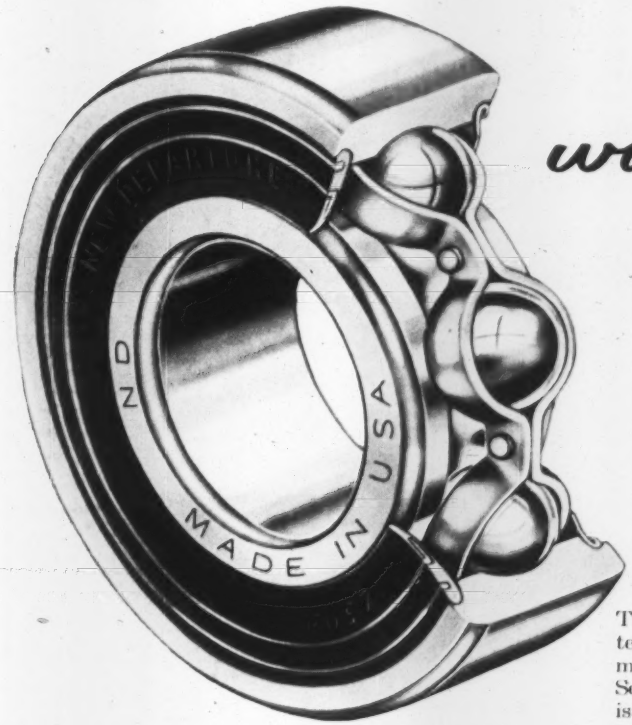
BOILER DIVISION

G-771

FACTS

about

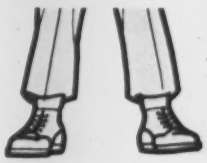
NEW DEPARTURE BALL BEARINGS



with

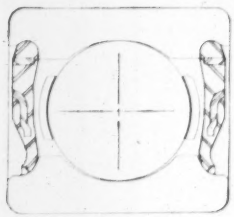
SENTRI-SEAL

on guard against dirt and wear!



The unique design of the Sentri-Seal gives optimum protection against dirt, and includes a number of other major advantages.

Sentri-Seals can be removed, easily replaced. As the seal is of synthetic rubber in which two metal rings are embedded, a constant-rate spring is created between the rings. Inherent flexibility prevents distortion of the bearing outer ring due to seal insertion, permitting the use of bearings to the higher accuracy specifications. The spring action maintains an efficient sealing contact with the bearing ring to bar dirt and retain lubricant. Sentri-Seals are relatively inert to oils and greases and operate satisfactorily through a temperature range of −40°F. to 225°F. Specifications available for still higher temperatures. In applications where relubrication is desired, it is easily accomplished by the injection method.



The diagram shows in section the New Departure Sentri-Seal. Lip-contacting surfaces are form-ground simultaneously with the ball race, giving an extremely high degree of concentricity between sealing surfaces and the raceway.

ONE SENTRI-SEAL | SEAL AND SHIELD | SEAL AND SNAP RING | TWO SEALS AND SNAP RING | SEAL, SHIELD AND SNAP RING

SEE "WIDE WIDE WORLD" SUNDAYS—NBC-TV

Sentri-Seal is available for a range of sizes in single-row, standard-width bearings and also in two types of New Departure adapter bearings. Sizes, dimensions and capacities are listed in the latest New Departure catalog.

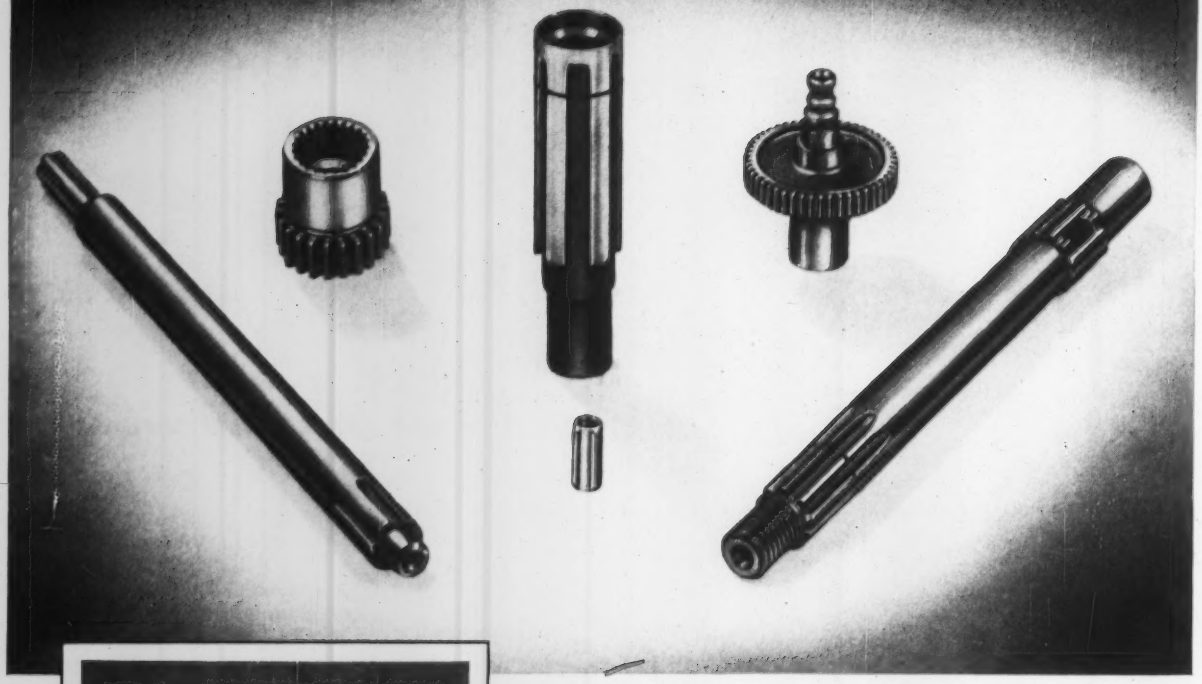
Write for full details on Sentri-Seal

BALL BEARINGS MAKE GOOD PRODUCTS BETTER

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

MECHANICAL ENGINEERING, March, 1957, Vol. 79, No. 3. Published monthly by The American Society of Mechanical Engineers, at 20th and Northampton Sts., Easton, Pa. Editorial and Advertising departments, 29 West 39th St., New York 18, N. Y. Price to members $3.50 annually, single copy 50¢, to nonmembers $7.00 annually, single copy 75¢. Add $1.50 postage to all countries outside the United States, Canada, and the Pan American Union. Entered as second-class matter December 21, 1920, at the Post Office at Easton, Pa., under the Act of March 3, 1879. Member of the Audit Bureau of Circulations.

Simple Or Intricate Splines and Serrations Are Jobs For G.S. ENGINEERING



GEAR
Specialties, Inc.
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CHICAGO 47, ILLINOIS

SPURS • SPIRALS • HELICALS • BEVELS • INTERNALS
WORM GEARING • RACKS • THREAD GRINDING

WORLD'S LARGEST EXCLUSIVE MANUFACTURERS OF FRACTIONAL HORSEPOWER GEARING

The extreme uniform accuracy of splines and serrations in G.S. Gearing is the result of 41 years of specializing in the mass-production of Small Gearing exclusively! Critical customers from coast-to-coast specify "G.S." again and again for the engineering skill and production efficiency only these long years of highly specialized experience can give. ★ The group of components shown above feature internal, external and involute splines and serrations. "Parallel Side" splines are multiple keys. They can be made to either a major diameter, minor diameter, or side fit with mating part. G.S. generates the externals by the hobbing or shaping process . . the internals by broaching or shaping. Involute splines are multiple integral keys having a pressure angle of 30°. They offer the advantage of greater strength. Involute serrations are essentially involute splines with 45° pressure angle. They are made for side fit applications only. ★ Whatever *type* of Splining or Gearing YOU require, however simple or intricate, you can place implicit confidence in G.S. to *consistently* supply TOP quality at moderate cost. Send drawings or descriptions today! Let our skilled engineers suggest the ONE best and most economical application for the job. There's no cost or obligation.

SEND FOR FREE *6-page Small Gearing Guide. It describes 80 types and applications. Contains useful charts . . a valuable aid to anyone interested in Small Gearing. Use company letterhead, please. No obligation, of course. Write today!*

FRACTIONAL HORSEPOWER GEARING

41 Years of Specializing in Small Gearing!

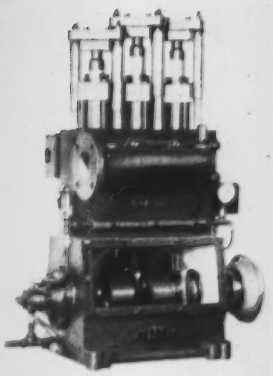
What you need here is an ALDRICH PUMP

The reliability of any central hydraulic system depends on the pump. If it's an Aldrich, you're sure of 100% availability of hydraulic power—with either oil or water.

Dependable service. Aldrich Pumps provide reliable, low-cost performance on such applications as die casting, hydraulic press operations, roll balancing, descaling and hydraulic testing. One reason is the simplicity of the Aldrich Direct Flow design, which permits horizontal straight-line flow from suction to discharge. Another is the reduced space between valves, which results in higher volumetric efficiency.

Easy maintenance. Fluid end sectionalization, changeable plunger sizes and interchangeability of parts provide fast, easy maintenance. Parts can be replaced easily and quickly, at low cost. Valves can be removed for inspection or replacement without special tools or equipment. Individual sections of the fluid end can be replaced at a fraction of the cost of conventional type fluid ends.

Get free details. Write today for a copy of Data Sheet 100, a condensed catalog and selection table covering our entire line. The Aldrich Pump Company, 29 Pine Street, Allentown, Pa.



Aldrich "Power-Pac" Direct Flow Triplex Pump has no equal in a nominal 25 hp pump for descaling, die casting, roll balancing, press operation, hydraulic testing. Pressures from 390 psi to 20,700 psi.

THE ALDRICH PUMP COMPANY

Here's what makes Bronze Valves

TYPICAL OF WALWORTH QUALITY is the union body-to-bonnet connection which stiffens the body against internal pressure; makes taking the valve apart a simple operation and reduces the chances of distortion or leakage even though the valve is repeatedly taken apart and reassembled. With this type of construction there is no possibility of the bonnet coming off the valve while the handwheel is being turned.

HEAVY BODY CONSTRUCTION is typical of *all* Walworth Bronze Valves. Extra-thick walls and rugged wrench hexes constitute a high safety factor and prevent distortion while the valve is being installed in the pipeline. Extra-deep pipe threads are accurately machined to eliminate leakage. Walworth Bronze Valves are also available with flanged, silver-brazed or soldered ends in certain sizes and types.

MEET THE CHAMP! The chief engineer of a midwestern plant had used a parade of valves in severe boiler blowdown service. Most didn't last longer than 60 days. None survived 90 days.

On the recommendation of a Walworth Representative the engineer installed the Walworth No. 225P Bronze Globe Valve shown here, stating that he would be entirely satisfied if it lasted a bare three months. Exactly 4 years and 362 days later the valve was taken out of service—not due to the wire drawing, steam cutting and galling which made the other valves short-lived—but because the highly turbulent steam finally wore a small hole in the body.

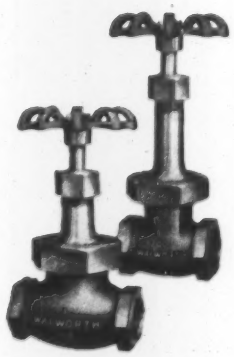
This is the kind of valve satisfaction you get—when you specify and use Walworth Bronze Valves. They are the longest wearing, toughest bronze valves on the market.

Walworth Subsidiaries: ALLOY STEEL PRODUCTS CO. • CONOFLOW CORPORATION • GROVE VALVE AND REGULATOR CO.

Walworth *the* real bargain!

EXTRA-LARGE STEMS with extra-long, extra-deep threads prolong valve life, protect against wear and distortion and provide tight positive shutoff. The surface of the stem is machined to a glass-like finish for minimum handwheel effort and to preserve the packing which results in fewer inspections and less maintenance. The top of the stem is tapered and squared to hold the handwheel securely.

TO REDUCE WIRE DRAWING to a minimum, certain types of bronze globe valves have stainless-steel plug-type seats and discs heat-treated to a nominal hardness of 500 Brinell, adding years to valve life even in severe services. These valves can be tightly closed on sand, grit or pipe scale without damage. Seats and discs are machined simultaneously, assuring perfect mating.

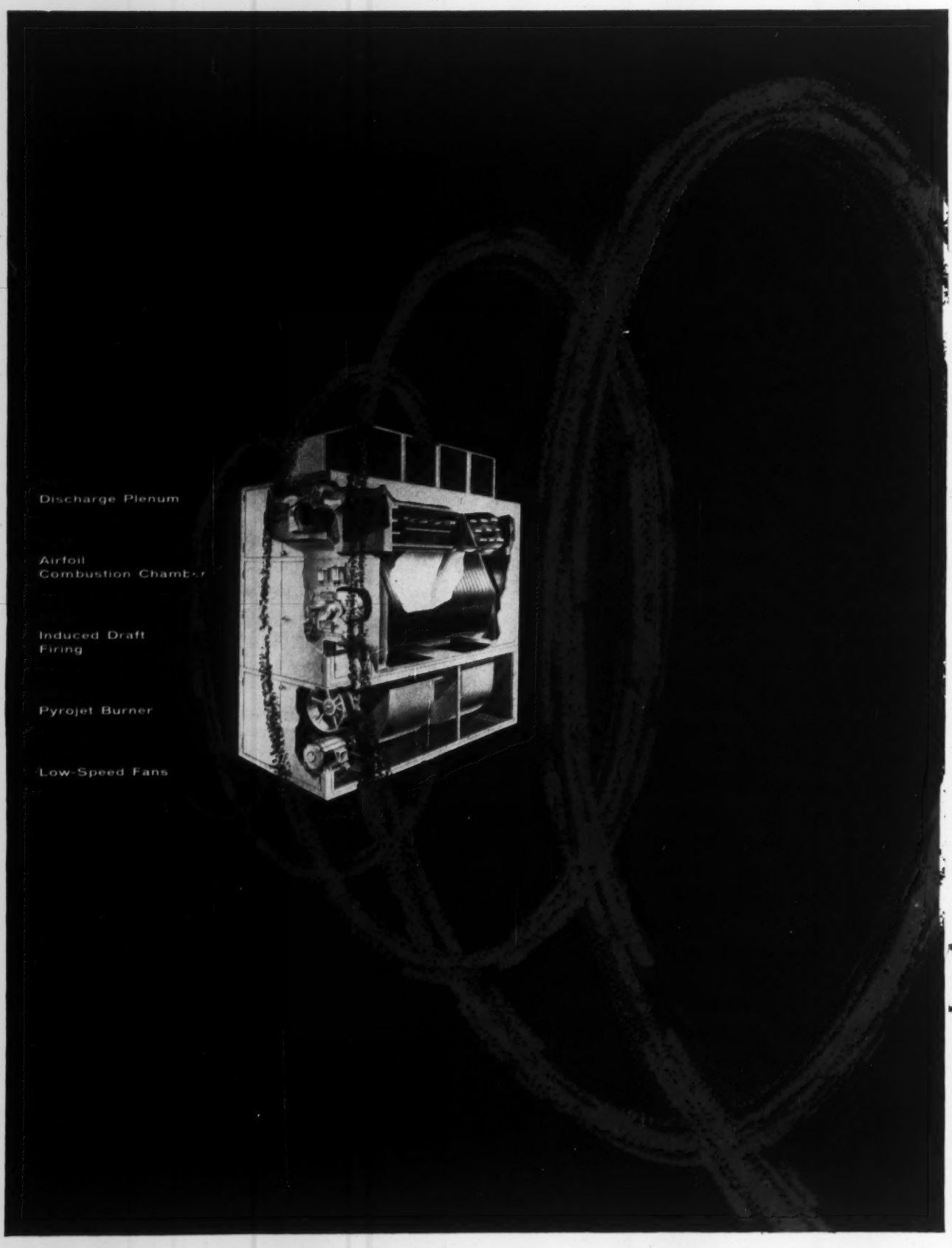


There is a Walworth Bronze Gate, Globe, Angle or Check Valve for every service. Walworth is continually developing new valve types and materials, including plastics, to keep pace with the growing variety and severity of services in modern industry. For full information, see your Walworth Distributor or write: *Walworth, 60 East 42nd Street, New York 17, N. Y.*

WALWORTH

Bronze Valves and Fittings

M & H VALVE & FITTINGS CO. • SOUTHWEST FABRICATING AND WELDING CO., INC. • WALWORTH COMPANY OF CANADA, LTD.


Discharge Plenum
Airfoil
Combustion Chamber
Induced Draft
Firing
Pyrojet Burner
Low-Speed Fans

Dravo presents: the first dual-fuel burner designed specifically for direct-fired heaters

PYROJET *burner tops list of features in all-new Dravo Counterflo heater*

Intensive research by Dravo engineers has resulted in the development of the first dual-fuel burner specifically designed for use in a direct-fired space heater. This burner, the PYROJET, burns light oil, heavy No. 5 oil, or gas with equal efficiency. The combination gas/light oil models feature automatic switchover with *no manual adjustment*. Here are some of the outstanding features of the Dravo PYROJET burner.

- Totally induced draft assures highest combustion efficiency
- Positive ignition of No. 5 oil provided by new dual pre-heater . . . another Dravo exclusive
- Automatic switchover on light oil/gas combination models . . . no manual adjustment
- Ring and finger design minimizes adjustment and service problems
- Combination of zero governor and gas-air premix block assures gas pilot stability
- Control options: on-off, hi-low-off, or full range modulation

Setting new standards of efficiency and convenience, the PYROJET burner is a major part of the entirely new concept of combustion achieved in the all-new Dravo *Counterflo* heater. The stainless steel, airfoil combustion chamber, the new induced draft system, the electronic controls, all contribute to make the new Dravo heater the most economical and flexible space heater available.

Write today for full information on this remarkable new Dravo heater. There is a size and type for every heater application—for economical space heating—for process heating—for tempering make-up air as a duct furnace and for a host of other applications. Address Dravo Corporation, Pittsburgh 22, Pennsylvania.

Ask for Bulletin 564-43

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CORPORATION

Blast furnace blowers • boiler and power plants • bridge sub-structures • cab conditioners • docks and unloaders • dredging • fabricated piping foundations • gantry and floating cranes • gas and oil pumping stations • locks and dams • ore and coal bridges • process equipment • pumphouses and intakes • river sand and gravel • sintering plants • slopes, shafts, tunnels • space heaters • steel grating • towboats, barges, river transportation

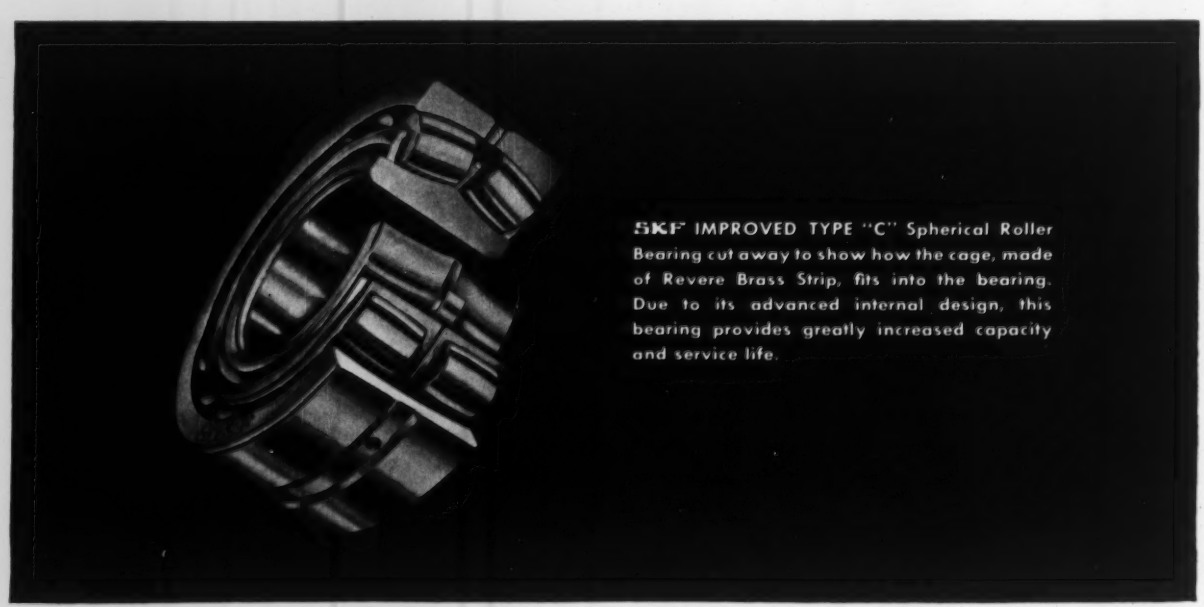
How SKF Saved in 7 Ways

and at the same time improved its roller bearing cages by using the right

Revere Brass Strip

SKF Industries, Inc., Philadelphia, Pa., like other progressive organizations, is constantly seeking new ways to improve its products and at the same time cut production costs.

With this in mind they recently reviewed the kind of brass which was being used in their spherical roller bearing cages from the standpoints of quality and fabrication. It was then that Revere's Technical Advisory Service studied the problem first-hand and made recommendations to the **SKF** production and engineering departments.



SKF IMPROVED TYPE "C" Spherical Roller Bearing cut away to show how the cage, made of Revere Brass Strip, fits into the bearing. Due to its advanced internal design, this bearing provides greatly increased capacity and service life.

HERE IS "window-type" cage of SKF Spherical Roller Bearing, made in two pieces, one for each row of rollers. Cage is made from rugged Revere Brass Strip at the Shippensburg, Pa., plant of SKF Industries, Inc.

The result was the adoption of specification changes in brass strip as recommended by Revere which gave SKF these 7 money, time and tool-saving advantages:

1. One bore pressing operation has been eliminated. Machining is more easily accomplished. Less machining is required.
2. Tool life has been increased with some speeds increased up to 100% and feeds up to 30%.
3. Rework due to burrs has been greatly reduced. One step less is required in the deburring operation while savings through reduced cycle time for remaining deburring operations are up to 40%.
4. Chips are small now . . . there is no "angel hair" to clutter work area.
5. Life of punch used in notching roller bearing cage has been doubled. Now a run may be completed without making tool adjustments due to sharpening tools.
6. Machining speeds and feeds have been substantially increased over those in machining the former alloy.
7. Die setters report that considerable work has been eliminated in setting up the tools used.

And, all of these money-saving things were accomplished without sacrificing quality—in fact the quality of these roller bearing cages was *improved!*

This is still another eye-opening example of Revere supplying the metal that will do the best job and with the greatest economy . . . be it brass, copper or aluminum or any one of their alloys.

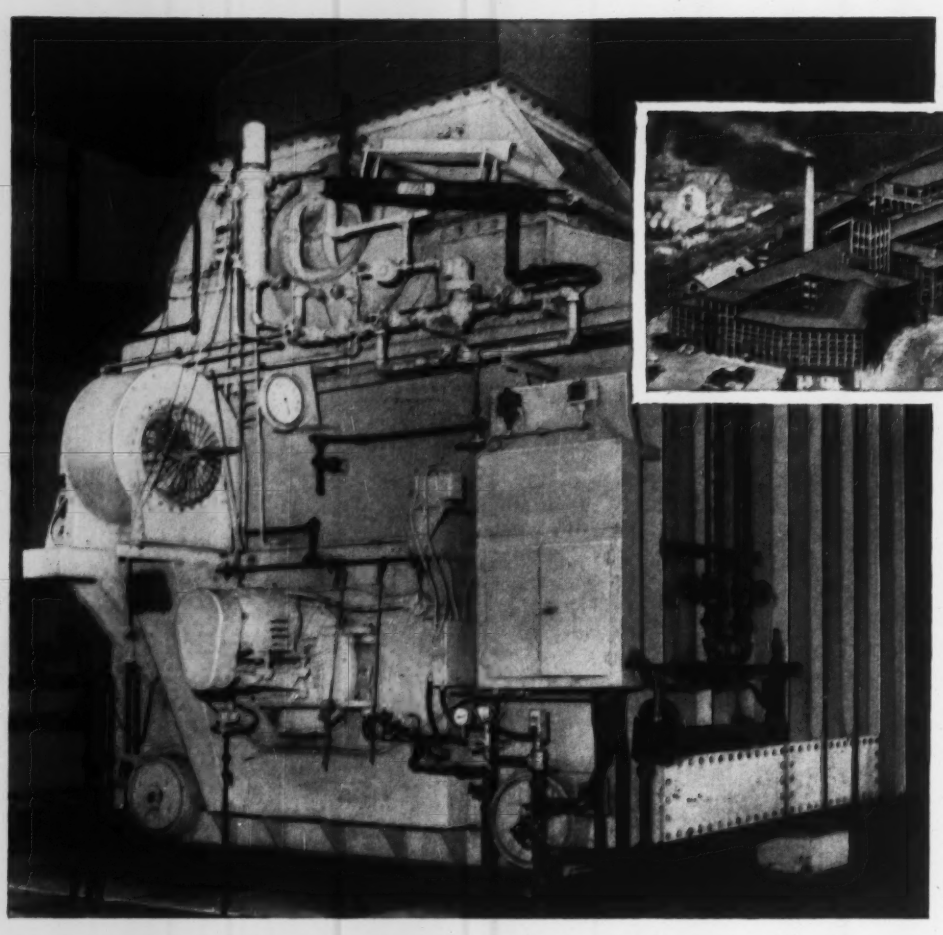
Why not call in Revere's Technical Advisory Service to review your operation? It may mean money saved with an improved product to boot.

REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801
230 Park Avenue, New York 17, N.Y.

Mills: Baltimore, Md.; Brooklyn, N.Y.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Newport, Ark.; Rome, N. Y. Sales Offices in Principal Cities, Distributors Everywhere.

COPPER • BRASS • 18 01 REVERE • ALUMINUM



AERIAL VIEW OF TORRINGTON'S EXCELSIOR PLANT, TORRINGTON, CONN. Torrington is world renowned for its manufacture of bearings, needles, bicycles and metal specialties.

ONE OF TWO UNION TYPE MH PACKAGED BOILERS serving Torrington's Excelsior Plant. Equipped for oil firing, this unit has a steam capacity of 15,000 lbs./hr. at 250 psi.

Torrington racks up $12,500 savings in year with first of two Union Packaged Boilers

Selected because its "construction and design appeared better than others . . . physical size fitted into plans," a 20,000 lb./hr. Union Type MH Steam Generator was installed in the Excelsior Plant of The Torrington Company in October, 1955.

Providing steam for process and space heat, the new boiler quickly proved its worth. In October 1956, as a second MH Unit (15,000 lbs./hr.) was placed in operation, Torrington had this to say about the first: "Estimated savings for the first year are $12,500, as compared to our old coal burning hand fired boilers."

Throughout industry, numerous concerns report like economies as the result of modernizing with modern Union Type MH Steam Generators.

Completely shop-assembled at Union Iron Works for delivery via rail or truck, Union Packaged MH Units are patterned after larger but similar field erected Type H Boilers, originated by Union over 17 years ago.

With standard units designed in 13 sizes from 10,000 to 50,000 lbs. of steam per hour, Union Packaged Steam Generators can be readily equipped to handle multitudes of needs formerly requiring costly field erection and special engineering.

GET FULL DETAILS including cut-away illustrations, tube layouts and dimension tables by writing for Bulletin MH-353.

UNION

UNION IRON WORKS

ERIE, PENNSYLVANIA

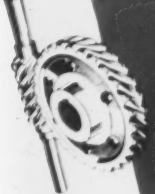
Right off the assembly line, these Philadelphia Pumps are ready for action. Driven by Speedaire . . . these rugged, heavy-duty pumps are assured of a sturdy power source.

SPEEDAIRE helps reduce cost of high pressure pump

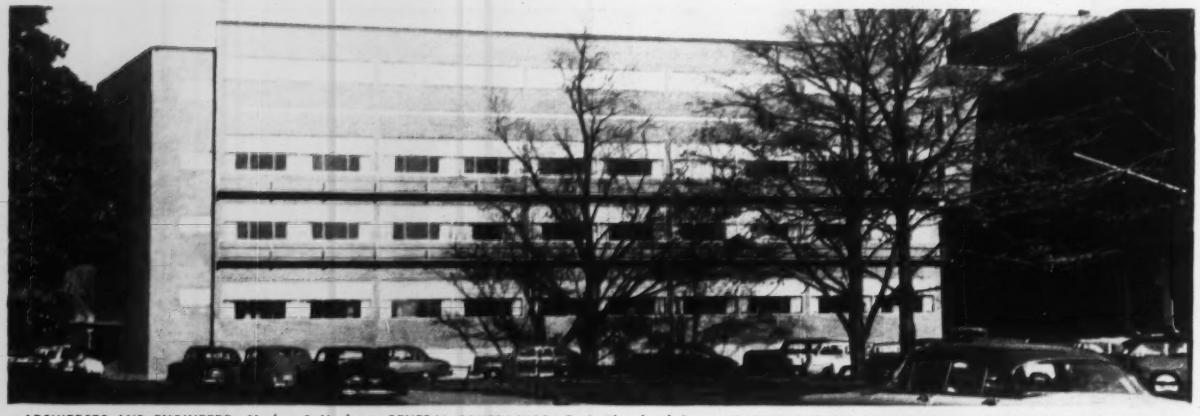
DESIGNED to operate at 3,000 p.s.i. pressure, this 50% metal slurry pump delivers 3 gallons per minute. Built to handle tough, unusual jobs, it is driven by a tough, unusual speed reducer—the Cleveland Speedaire. Not only did Speedaire offer the smaller frame size needed for this unit, it also helped substantially to reduce its price. Speedaire costs hundreds of dollars less than a conventional drive of comparable capacity.

Further, the fan-cooled Speedaire worm gear reducer runs cool and smoothly under a heavy load, unaffected by heat, moisture and grime. Thousands are in service. Chances are you can use one or more right now! If you aren't familiar with Speedaire, just call us. Ask for a copy of Catalog 400. The Cleveland Worm and Gear Co., 3264 East 80th St., Cleveland 4, Ohio.

Affiliate: The Farval Corporation, Centralized Systems of Lubrication. In Canada: Peacock Brothers Limited.



CLEVELAND
Worm Gear
Speed Reducers



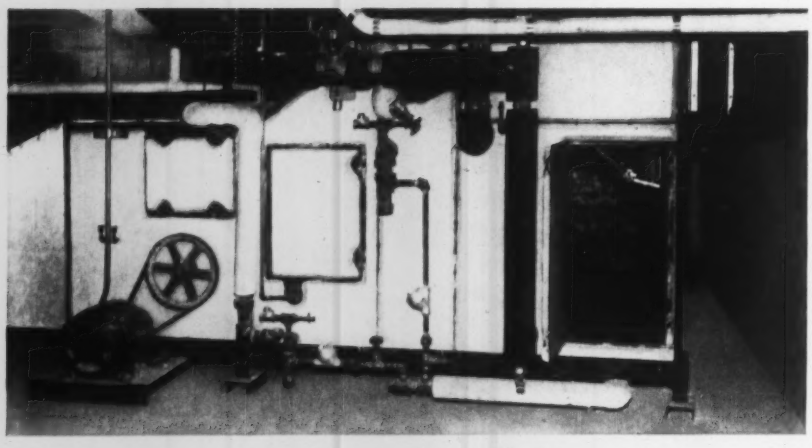
• ARCHITECTS AND ENGINEERS—Markus & Nocka • GENERAL CONTRACTOR—E. C. Blanchard Co. • HEATING AND AIR CONDITIONING CONTRACTOR—E. J. Devlin Co.

NEW HOSPITAL WING

Completely Zone Controlled

BY 7 CLARAGE AIR CONDITIONING UNITS

Plans for the new Garfield Morgan Memorial Wing to the Lynn Hospital at Lynn, Massachusetts called for complete air conditioning. As for so many other prominent installations, Clarage Blow-Thru Multitherm Units—seven of them—were selected. Here is equipment fully equal to the requirements of this important assignment. Quiet . . . economical in operation . . . and, most assuredly, dependable. CLARAGE FAN COMPANY, Kalamazoo, Michigan.

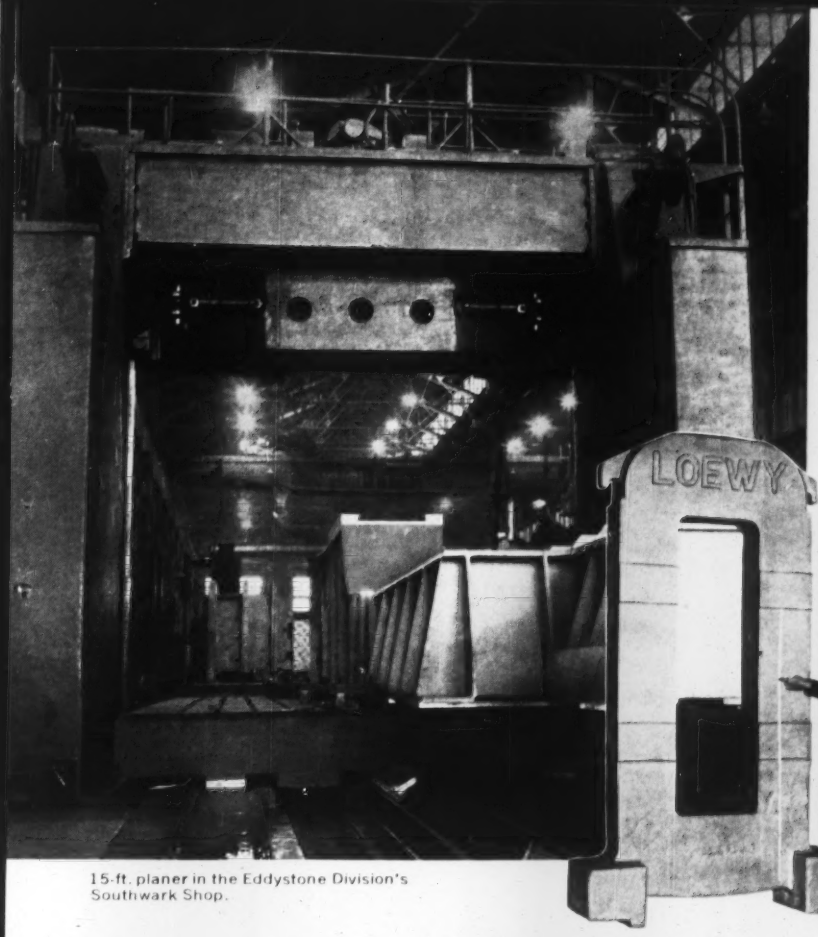


8 ZONES

This ONE Clarage Blow-Thru Multitherm Unit serves the specific air conditioning requirements of EIGHT different zones on the fourth floor which is the operating suite. Mixing dampers for each zone are interconnected so that the thermostat in each area controls the blending of hot and cold air to maintain the desired room temperature. Automatic damper operators can be seen through the open inspection door.

CLARAGE ... *dependable equipment for making air your servant*

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal



15-ft. planer in the Eddystone Division's Southwark Shop.

General Machine Shop at the Eddystone Division, Eddystone, Pa., whose 1,500,000 square feet of manufacturing space includes huge fabrication shops and a nonferrous castings foundry.

•

Blooming an ingot at the Standard Steel Works Division, Burnham, Pa., under one of the 2500-ton hydraulic presses.

Vast, integrated Baldwin-Lima-Hamilton facilities enable Loewy-Hydropress to deliver your rolling mills on time

When Loewy-Hydropress designs and builds your rolling mills, you aren't plagued by the usual troublesome and expensive delivery delay. For Loewy has at its disposal the vast, yet smoothly integrated resources of the entire Baldwin-Lima-Hamilton Corporation.

The two B-L-H divisions called upon most frequently to make parts for Loewy-designed rolling mills are the Standard Steel Works and Eddystone Divisions. The necessary steel components are cast or forged at Standard. And Eddystone, with its extensive machining facilities, supplies the completely finished nonferrous castings and weldments. Other members of the B-L-H family with excellent facilities for producing rolling mill parts are the Hamilton Division, Hamilton, Ohio; the Austin-Western Division, Aurora, Ill.; and the Madsen Division, La Mirada, Calif.

Close coordination among all Baldwin-Lima-Hamilton divisions is the chief reason why Loewy-Hydropress can deliver your rolling mills faster.

To your individual production requirements, we design, build and install hot and cold rolling mills for ferrous and nonferrous metals, continuous merchant and wire-rod mills, skelp mills, two-high and three-high blooming mills, high-speed foil mills, continuous billet and sheet-bar mills, strip, slabbing, plate, structural, rail mills, and special mills. Write us today, Dept. F-3, for illustrated bulletin L-164.

Loewy-Hydropress designers at the company's headquarters in New York City.

Loewy-Hydropress Division

BALDWIN · LIMA · HAMILTON

111 FIFTH AVENUE, NEW YORK 3, N.Y. Rolling mills • Hydraulic machinery • Industrial engineering

BALDWIN BLH LIMA-HAMILTON

Planetary Roll and

complements the Foster Wheeler line of pulverized fuel systems

THE FOSTER WHEELER Type MB planetary roll and table pulverizer, developed in Germany, is a constant-speed mill which has proved to be exceptionally efficient and economical to operate and maintain.

In the MB pulverizer, grinding action takes place between a slowly rotating horizontal table and three spheroidal rollers, uniformly spaced around the axis of the table and subjected to controlled thrust pressure by a large number of coil springs. The motion of the table causes the rollers to rotate while circling planet-fashion and rolling over the material on the grinding ring.

Air or gas, entering from below the pulverizer table, floats the ground particles up into the classifier, located in the top of the housing. Particles too coarse to float fall back onto the table for further pulverization. All routine adjustments to the spring tension gear or classifier vanes can be made externally while the mill is in operation.

Wide experience abroad indicates that this new addition to the complete line of heavy-duty FW pulverizers offers the following advantages.

1. *Low Power Consumption*
   Assures exceptional economy of operation, year after year.

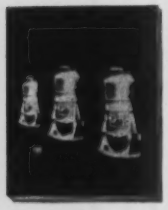
2. *Low Maintenance*
   Extremely rugged construction and accessibility of wearing parts reduces down-time for servicing.

3. *Uniform Product Fineness*
   Pulverizer and classifier design assures extreme uniformity of particle size.

4. *Pressurized or Suction Operation*
   Provides complete flexibility for various types of service.

5. *All Necessary Adjustments Made Externally with Mill Operating*
   Avoids shut-downs for changes in pulverizer pressure or classifier adjustment.

6. *Simple Renewal and Replacement of Grinding Rolls and Table*
   Cuts down-time for infrequent replacement of wearing parts.



THE TYPE MB PULVERIZER, with Foster Wheeler feeders, distributors, burners and fans or exhausters, provides an exceptionally efficient and economical pulverized fuel system.

For complete information on the new PLANETARY ROLL & TABLE PULVERIZER, write for Bulletin MB-55-5.

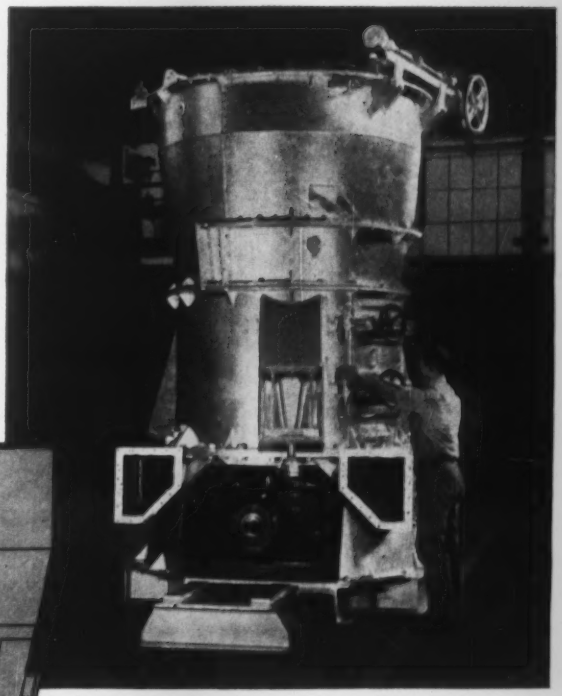
For full details on Foster Wheeler heavy-duty BALL MILL pulverized fuel systems, write for Bulletin BP-53-3.

Foster Wheeler Corporation, 165 Broadway, New York 6, N.Y.

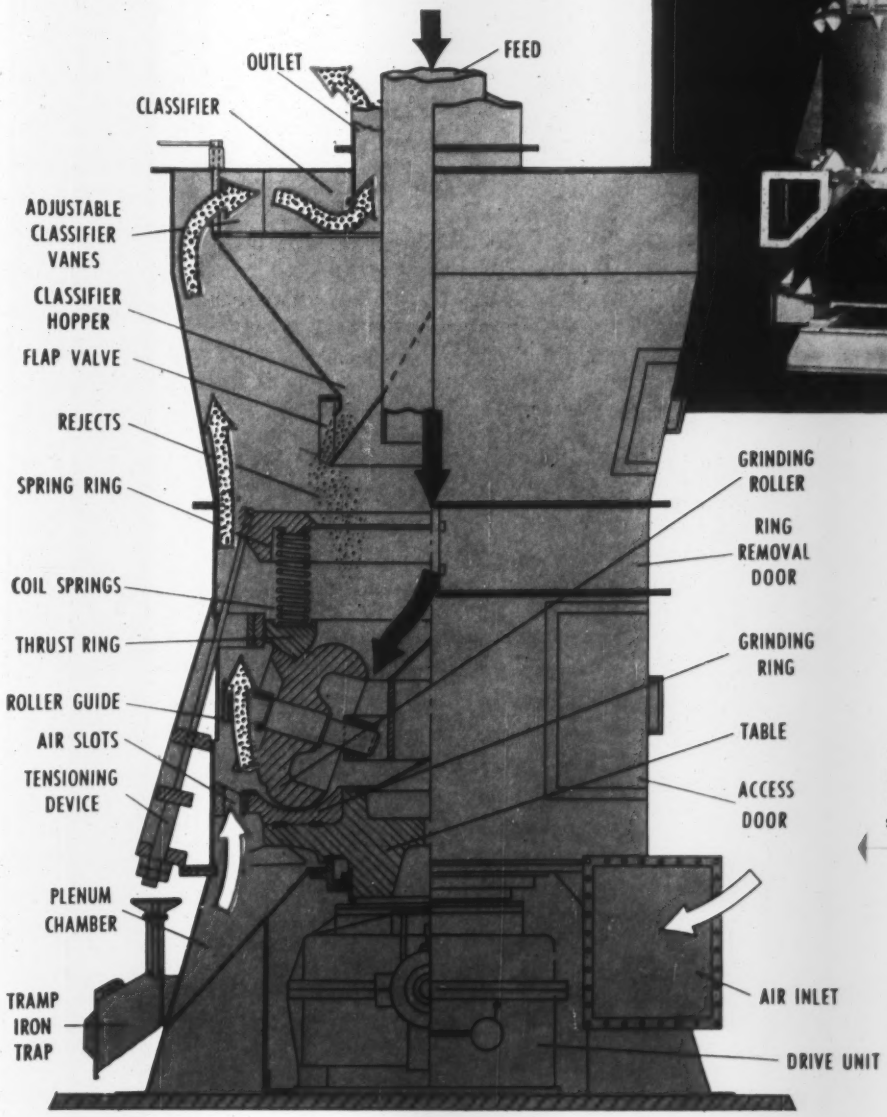
FOSTER WHEELER

NEW YORK • LONDON • PARIS • ST. CATHARINES, ONT.

Table Pulverizer



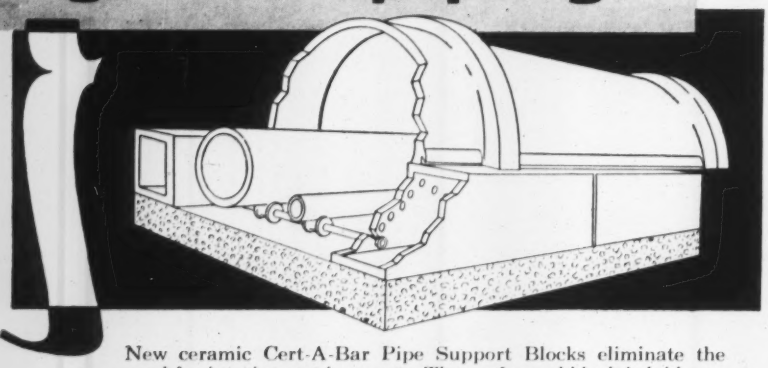
Exterior view of completely assembled Foster Wheeler Type MB planetary roll and table pulverizer.



Sectional drawing of Type MB pulverizer with parts identified to show construction and operation.

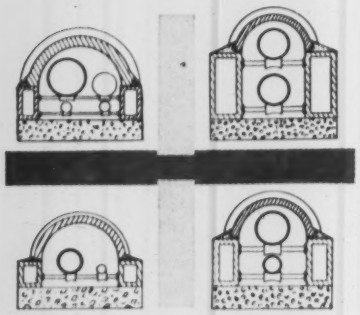
PERMANENT PROTECTION
for underground piping!

STILLWATER CERT-A-BAR* TUNNEL CONDUIT SYSTEM



New ceramic Cert-A-Bar Pipe Support Blocks eliminate the need for interior cast iron rests. The perforated block is laid as a structural support member at regular intervals, and the bars are simply inserted and locked in place.

THE vital consideration in selecting an underground conduit system is *permanent* protection . . . not for one year or five, *but for the life of the piping.* You get the best possible protection for your underground metal service piping with a Stillwater Conduit System of vitrified clay. It's chemically inert—can't rust, rot, corrode, or decay . . . ever. And it is manufactured in accordance with ASTM specification C-13-54, assuring proper strength and quality. Any combination of service piping can be protected. Conduit is available in a wide range of sizes, with a complete line of fittings and accessories, including alignment guides, lateral guides, and anchors. Any contractor's crew can handle the installation easily, or if you prefer, Stillwater Licensed Installers will assume the responsibility. The Cert-A-Bar Tunnel System can be installed with any of three suggested new waterproofing specifications —one for average conditions, one for intermittent ground water conditions, and a third for high water table conditions. It's the lowest-cost conduit per year of service that you can specify or install!



THE CERT-A-BAR SYSTEM HAS ALL THESE IMPORTANT ADVANTAGES

- Inherent structural strength for permanent protection
- Complete flexibility for design
- Minimum initial and long-term costs
- Quickly installed
- Keeps pipe insulation dry
- No electrolytic corrosion of piping
- No maintenance required

A few of the hundreds of possible combinations of piping for the Cert-A-Bar Tunnel System are shown at left.

WRITE FOR

illustrated, four-page circular with complete installation specifications.

*T.M. Reg. App. For. Patents Pending

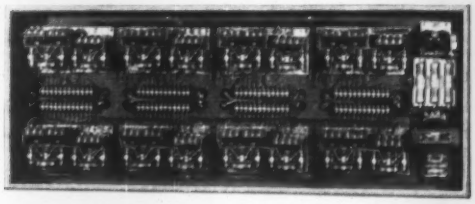
The Stillwater Clay Products Co.
STILLWATER CONDUIT DIVISION
3348 PROSPECT AVENUE, CLEVELAND 15, OHIO

SW 956 70A

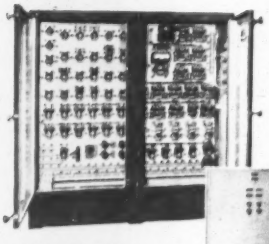
STILLWATER CONDUIT SYSTEMS

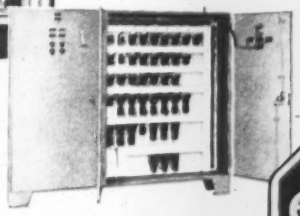
for trouble free operation—

let ALLEN-BRADLEY build your Special Control Panels



Motor control panel for a multiple head drill press using Allen-Bradley quality components.





Two Allen-Bradley control panels for operating an automation assembly of machine tools.

When the control panel furnished with your production machine carries the Allen-Bradley trademark of QUALITY, your customer's approval is assured! That is why so many leading machinery builders have standardized on Allen-Bradley controls. The "simple design" of all Allen-Bradley controls is your guarantee of trouble and maintenance free service.

No matter how complex your control requirements may be, as specialists in this field, Allen-Bradley's experience may be of valuable assistance to you. Call your nearest A-B office.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

ALLEN-BRADLEY

QUALITY

MOTOR CONTROL

A-B Quality

3-57 B

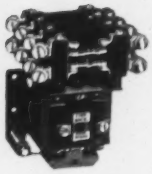
"we'll use

ALLEN-BRADLEY

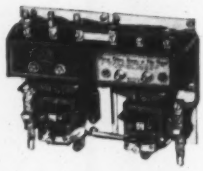
Quality Motor Control

...it's trouble free!"

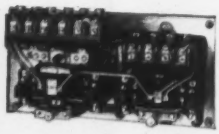
SPECIFY THESE RELIABLE MOTOR CONTROL UNITS



Bulletin 700
Universal Relay with
N.O.—N.C. Contacts



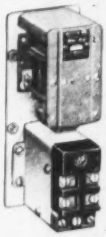
Bulletin 705 Size 2
Reversing Starter



Bulletin 715 Two
Speed Consequent
Pole Starter

Bulletin 802T Adjustable
Lever Oiltight Limit
Switch

Bulletin 702 Three Pole
Size 2 Contactor

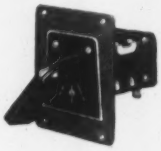


Bulletin 849 "On-Delay"
Pneumatic Timer

Bulletin 892
Handy Terminal
Blocks

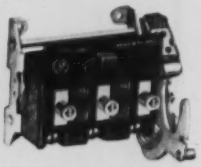
Bulletin 704, Mechanically
Held, Hum-free Relay

Bulletin 200
D-C Relay

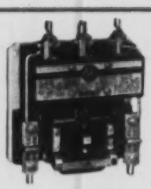


Bulletin 350
Reversing Drum Switch

Bulletin 836
Pressure Control in
NEMA Type 4 Enclosure



Bulletin 894
Visible Blade
Disconnect Switch



Bulletin 709
Size 4 Automatic
Starter

Bulletin 609
Three Phase
Manual Starter

Oiltight Push Button, Selector Switch, Press-to-Test
Pilot Light, and completely assembled Oiltight Station

Allen-Bradley *quality* components assure you millions of trouble free operations. The simple design, maintenance free, double break, silver alloy contacts, and rugged design features have made them the first choice among design engineers, contractors, and maintenance men. You just can't go wrong with this QUALITY line.

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
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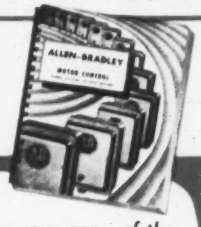

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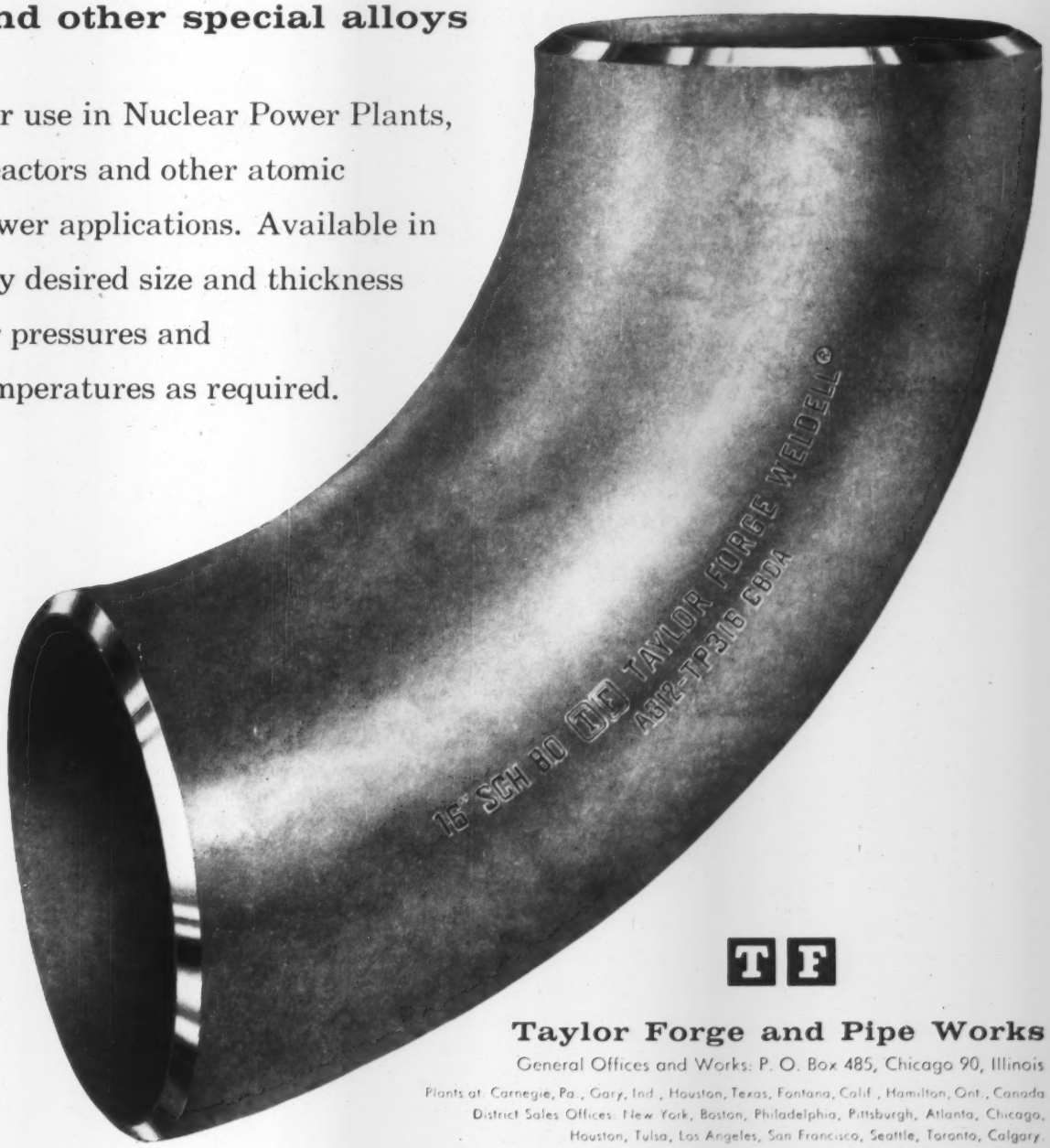
Welding Fittings and Forged Flanges in STAINLESS STEEL

and other special alloys

For use in Nuclear Power Plants, Reactors and other atomic power applications. Available in any desired size and thickness for pressures and temperatures as required.



Taylor Forge and Pipe Works

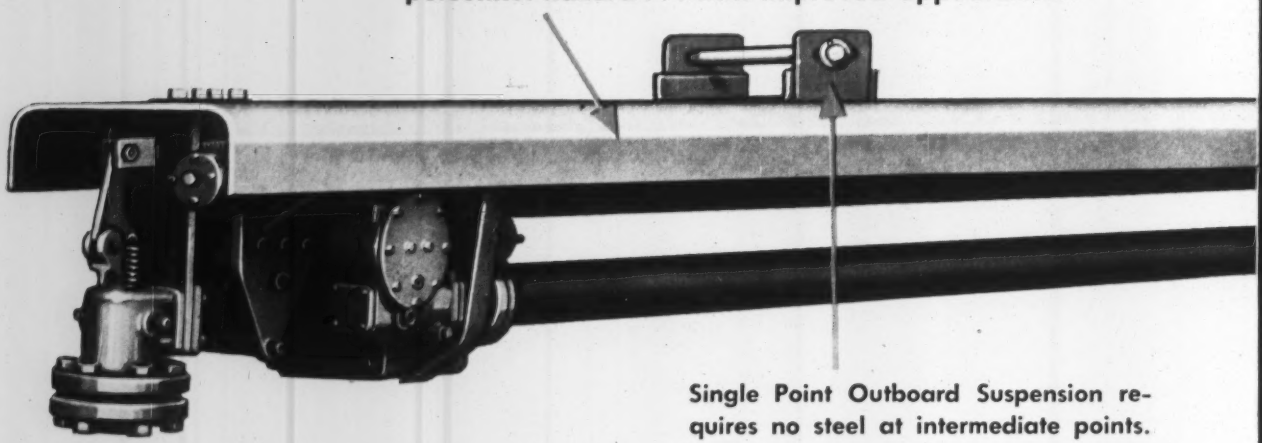
General Offices and Works: P. O. Box 485, Chicago 90, Illinois

Plants at: Carnegie, Pa., Gary, Ind., Houston, Texas, Fontana, Calif., Hamilton, Ont., Canada

District Sales Offices: New York, Boston, Philadelphia, Pittsburgh, Atlanta, Chicago, Houston, Tulsa, Los Angeles, San Francisco, Seattle, Toronto, Calgary.

Backbone and Protective Cover

Top Cover is an integral part of the structural "Backbone" of the blower unit that assures greater rigidity. It also provides protection from dirt, damage, the elements, and personnel hazard . . . with improved appearance.



Single Point Outboard Suspension requires no steel at intermediate points.

One of the most popular features of the new Diamond Series 300 IK Long Retracting Blower is the very substantial cover that is formed from steel plate. It is much more than just a cover in the ordinary sense . . . it is also an integral part of the structural backbone of the blower that provides maximum rigidity without excessive weight.

This is only one of many important features (see box on right hand page) of the new Series 300 IK that is establishing a new standard of efficiency, economy and dependability in cleaning those heating surfaces that require a long retracting blower. For further information about the new Series 300 IK, ask the nearest Diamond office for Bulletin 2111AA.

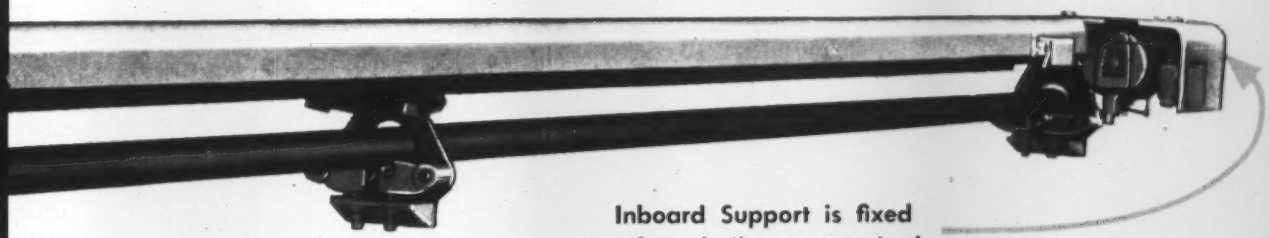
Diamond

DIAMOND POWER SPECIALTY CORP.

LANCASTER, OHIO

Diamond Specialty Limited • Windsor, Ontario

ANOTHER IMPORTANT FEATURE of the NEW Diamond SERIES 300 IK LONG RETRACTING BLOWER



Inboard Support is fixed
or from boiler, as required.

"YOU CLEAN BOILERS BETTER AND AT LOWER COST WITH DIAMOND BLOWERS"

OTHER ADVANTAGES OF SERIES 300 IK BLOWERS

- Front End Single-Motor Drive
- Compact, Accessible Electric or Air Power and Control Terminal Facilities
- Nozzle-Sweep-Every-Inch Cleaning Pattern
- Improved "Type A" Nozzle
- Positive Gear Carriage Drive
- Poppet Valve with Adjustable Pressure Control
- Positive Mechanically Operated Valve
- Single Point Outboard Suspension
- Oversize Lance (Step-Tapered for Extra Long Travel)
- Auxiliary Carriages for Extra Long Travel
- Designed for Quick, Easy Servicing

No other blower gives you all these advantages.

7697

Catalyst material is handled by an S-A zipper conveyor belt which automatically opens to receive material which is then carried to discharge completely enclosed and protected. The belt "unzips" and discharges catalyst into reactor.

Mobile Zipper Elevator for swift economical and gentle handling of catalyst materials by STEPHENS-ADAMSON

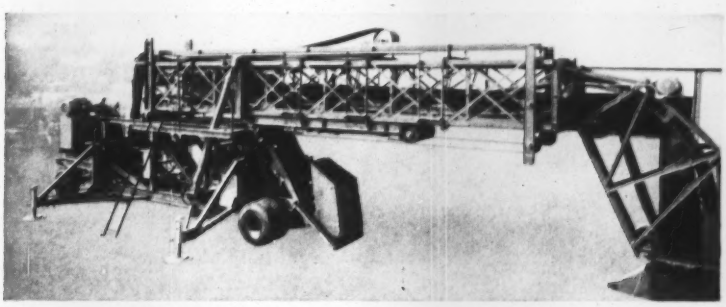
Cracking plant operators call it the "Dinosaur," a pseudonym applied because of this remarkable machine's physical appearance.

Actually it is a highly mobile conveyor-elevator unit designed to charge catalyst materials to cracking plant reactors.

While its first application has been by petroleum refineries, it is obvious that the "Dinosaur" can be used wherever comparatively light, dry bulk materials must be elevated and delivered to a manufacturing process, or to storage.

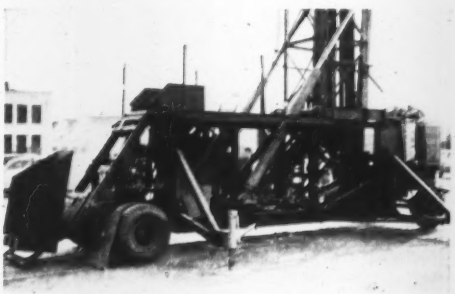
Under certain conditions, it can do the job required of far more costly permanent material handling installations, requires only a fraction of the operating personnel, and eliminates all manual loading above grade level. Its telescoping boom can be extended from 45 to 70 feet vertically and can be stowed on the carriage while the unit is travelling.

While the "Dinosaur" is an unusual machine it is also indicative of the creative latitude of STEPHENS-ADAMSON engineers. It is the result of combining engineering and manufacturing skills to create the most sensible answer to a material handling problem. S-A has been designing and building conveyor systems for over fifty years. In the whole world of bulk material conveying, there are no problems that cannot be or have not been solved the S-A way.



The "Dinosaur" can be stowed in horizontal position and the entire unit moved easily and conveniently from station to station. Material is loaded mechanically by means of a barrel dumper which completes a cycle every 45 seconds. The elevator will deliver catalyst at a rate of 15 to 30 TPH depending on cubic foot density. Rate is based on belt speed of 150 FPM. Machine weighs 30,000 lbs.

The only power source required for the motor starter and power plant is a 440 volt, 3 phase, 60 cycle plug with sufficient conductor size to handle 35 H.P. All motors and switches are explosion proof.



Unit is provided with outriggers for maximum stability. Access to working platform is gained by means of an auxiliary ladder. Pallets of bagged material may be lifted to platform by forked truck for manual loading, if desired.

STEPHENS-ADAMSON MFG. CO.

19 RIDGEWAY AVENUE, AURORA, ILLINOIS
LOS ANGELES, CALIFORNIA
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ENGINEERS AND MANUFACTURERS OF BULK MATERIAL CONVEYOR SYSTEMS FOR OVER 50 YEARS

• S-A manufactures a wide range of material handling products in three complete plants in U. S. and Canada

Belt Conveyors	Conveyor Belt Cleaners
Belt, Pan & Plate Feeders	Headshaft Holdbacks
Ship Loading Boom Conveyors	Grizzlies & Screens
Stacking Conveyors	Centrifugal Pilers
Storage & Reclaiming Systems	Bin Gates & Tunnel Gates
"Natural Frequency" Vibrating Conveyors	Car Pullers & Spotters
REDLER Conveyor-Elevators	Bucket Elevators
ZIPPER Conveyor-Elevators	Skip Hoists
	SEALMASTER Ball Bearing Units

• *Write for a bulletin on any of the above products.*

Argonne National Laboratory Experimental Boiling

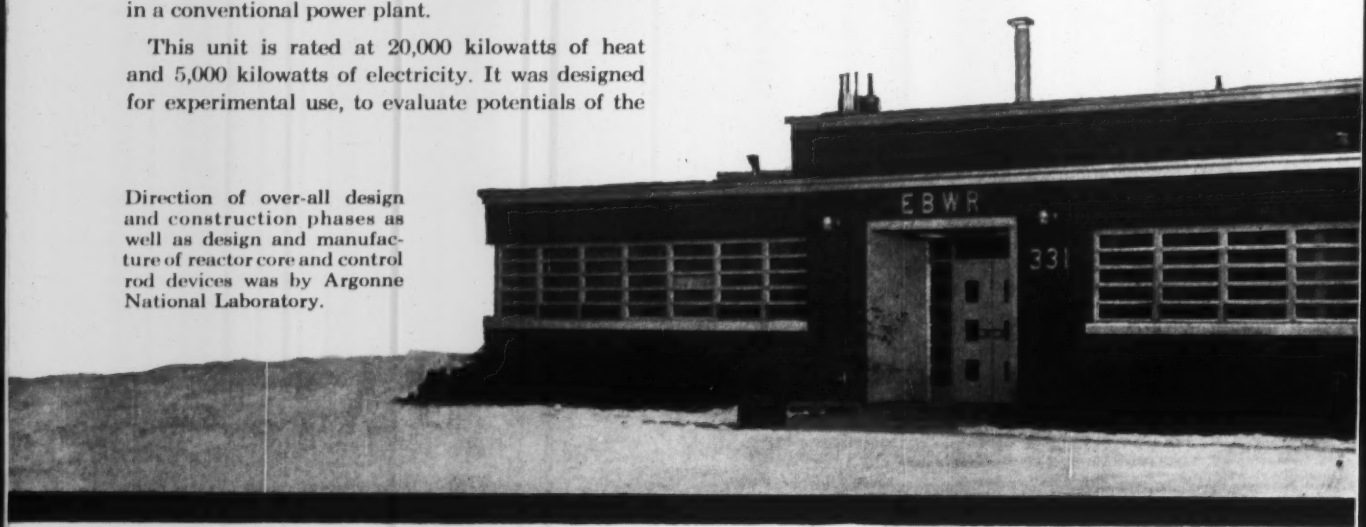
Electricity from NUCLEAR POWER TODAY!

NOW in operation at Lemont, Illinois, this is the first commercial-type power plant in the United States to generate usable quantities of electric power from nuclear fuels.

The unique feature of this boiling water reactor is that live steam is actually generated in the uranium core by nuclear heat and piped directly to the turbine without need for intermediate heat exchangers as required by other types of reactors. In effect, it operates very much like the coal-fired boiler in a conventional power plant.

This unit is rated at 20,000 kilowatts of heat and 5,000 kilowatts of electricity. It was designed for experimental use, to evaluate potentials of the boiling water reactor for large-scale commercial applications. Power generated is used by the Laboratory to meet a portion of its own electric power requirements.

Allis-Chalmers is proud of its association with this significant project. It's another example of "Engineering in Action" to provide power for better living from any source, whether it be water, steam, oil, or the atom itself.

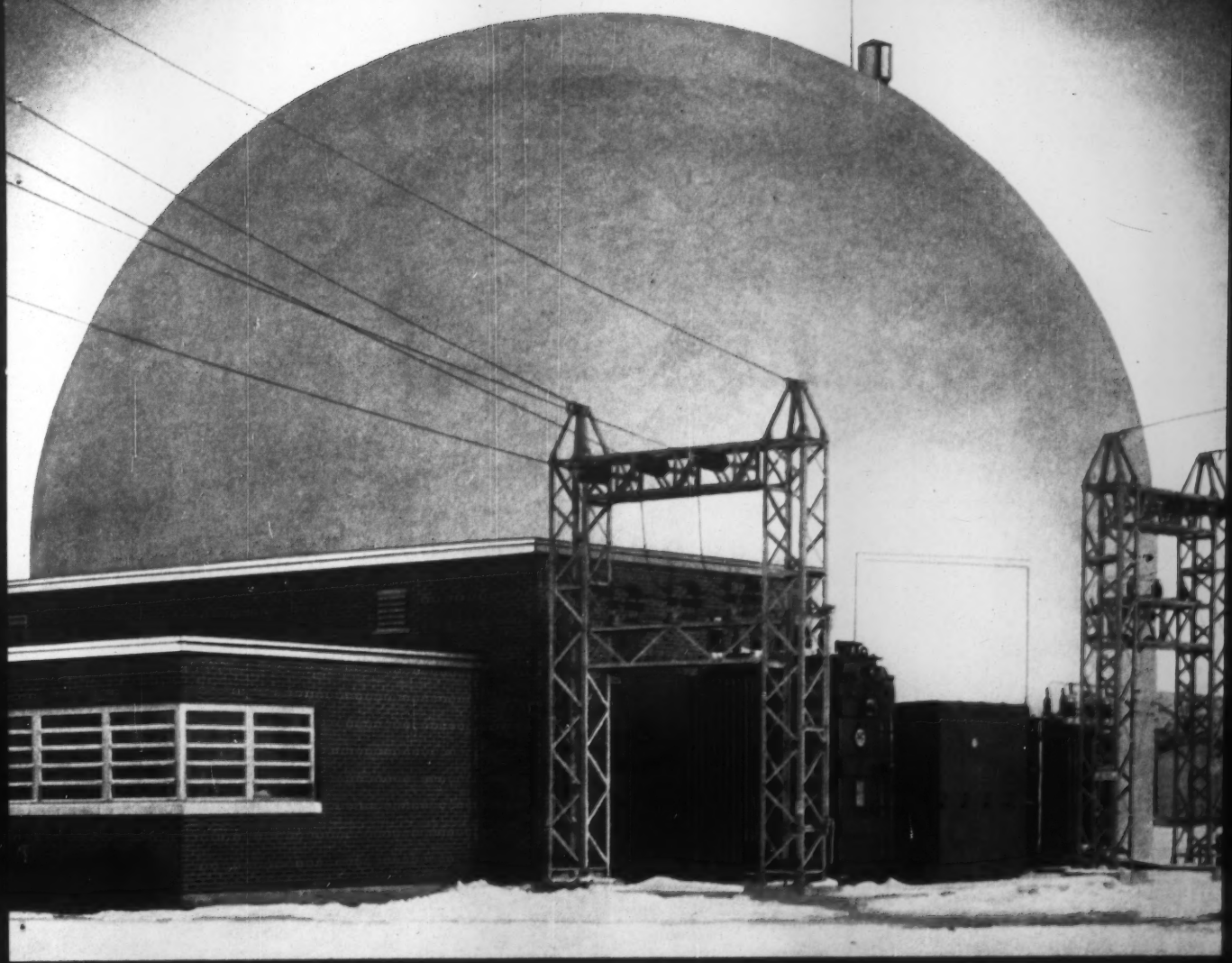


Direction of over-all design and construction phases as well as design and manufacture of reactor core and control rod devices was by Argonne National Laboratory.

Power Equipment Supplied by Allis-Chalmers

- Steam turbine generator and exciter
- Surface condenser and air ejectors
- Complete control center for remote operation of reactor and power equipment
- Reactor water recovery and air drying system
- Reactor steam bypass control system
- Hermetically sealed pumps for reactor purification system
- Reactor feedwater pumps
- Circulating water pumps
- Auxiliary cooling water pumps
- Motor control centers
- Main and reserve power transformers
- Indoor and outdoor switchgear
- Automatic voltage regulator
- Circulating water treatment system
- Ac-dc distribution center
- Diesel-generator set

Water Reactor in Full Operation



ALLIS-CHALMERS

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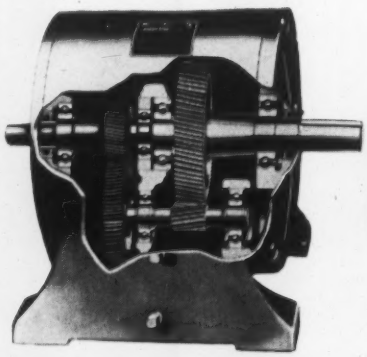
WESTERN GEAR-O-GRAM

NEW PRODUCT NEWS

INVESTIGATE ADVANTAGES NEW WESTERN GEAR STRAIT-LINE SPEED REDUCERS STOP COMPACT IN-LINE DRIVES SIGNIFICANT ADDITION TO WESTERN GEAR LINE OF QUALITY POWER TRANSMISSION PRODUCTS STOP SEND FOR FULL INFORMATION STOP ASK FOR BULLETIN 5616=

WESTERN GEAR STRAIT LINE SPEED REDUCERS

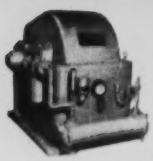
Double Reduction Type RD



Cutaway View Double Reduction Type RD

Triple Reduction Type RT

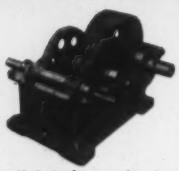
...And here are other members of the **WESTERN GEAR** *quality line of mechanical power transmission equipment. They're tops in dependability, backed by 69 years of experience!*



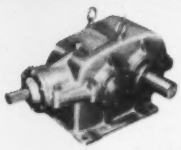
High speed unit

Integral gearmotor

All motor gearmotor



Parallel shaft speed reducer



Right angle speed reducer

Vertical speed reducer

"The difference is reliability" • Since 1888

5751

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ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.) SEATTLE AND HOUSTON — REPRESENTATIVES IN PRINCIPAL CITIES

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P.O. Box 182, Lynwood, California

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These three Lectrodryers® feed a constant flow of CLEAN, DRY air to 125 dryboxes where electronic components are assembled at Texas Instruments, Incorporated, Dallas, Texas.

DRYness surrounds, and is hermetically sealed inside of germanium and silicon transistor rectifiers and diodes assembled here. No moisture to impair their dependability!

DRYing clears the atmosphere for Crystal Gazers

2% relative humidity or less is the DRYness of air fed to these dryboxes. Three Lectrodryers do that DRYing—continuously, economically.

Is moisture bothering your present processes or are you planning for the future? To learn what DRYing will do for you, write Pittsburgh Lectrodryer Company, 335 32nd Street, Pittsburgh 30, Pennsylvania (a McGraw-Edison Co. division).

Lectrodryer

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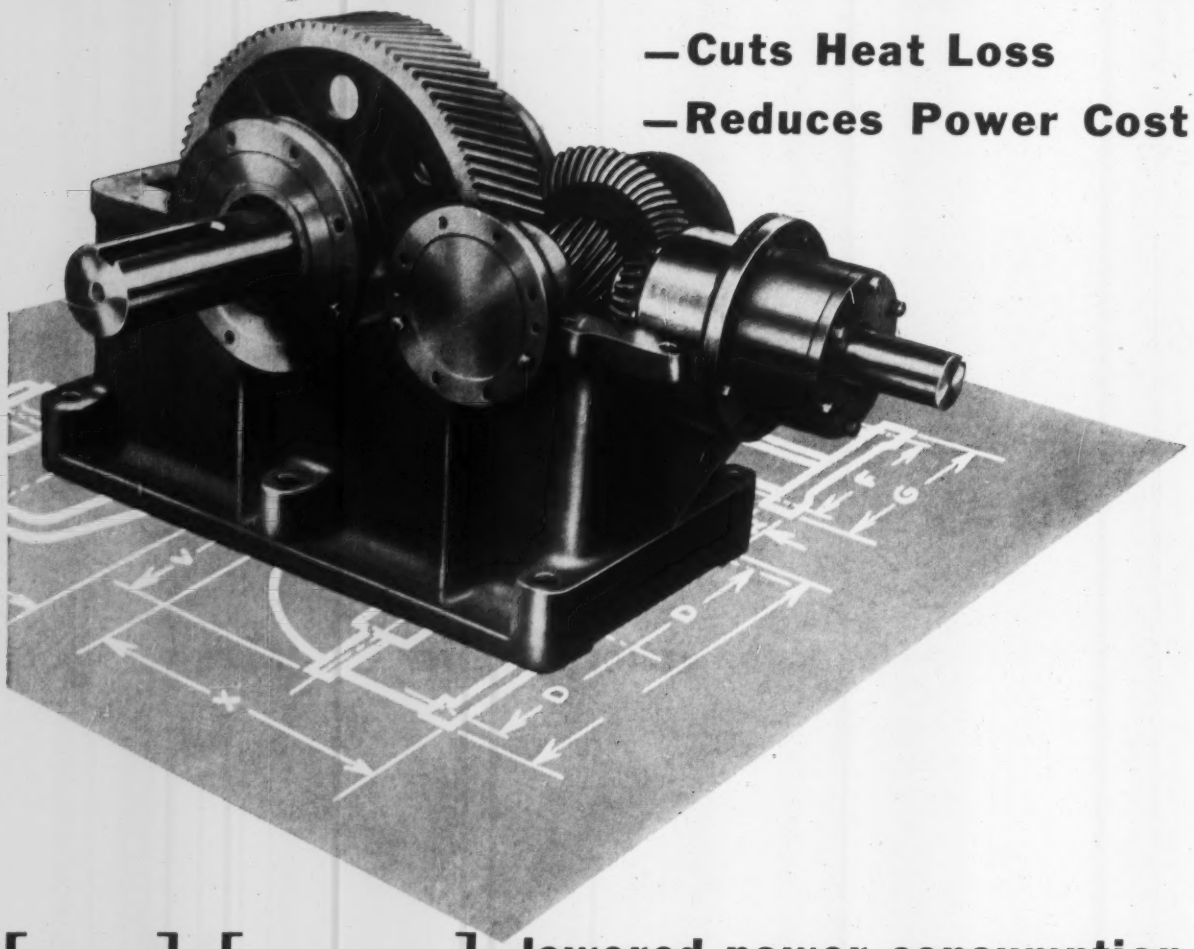
Maximum Efficiency In Right Angle Drives

—Cuts Heat Loss

—Reduces Power Cost



[advanced design] + [manufacturing skill] = lowered power consumption and reduced prime-mover cost

A glance at the illustration will readily convince you of the plus features of these quality "custom-built" units. Spiral-Bevel and Helical Gearing assures quiet operation at high speeds, and increased tooth strength. Pinion shafts are integral with gears and finished to close tolerances by grinding. Ball or Roller Bearings support shafts and are designed to take combined radial and thrust loads. Housings are quality grey cast iron with all points of stress properly ribbed to reduce deflections and stresses to minimum; also housing design provides adequate oil reservoir and large radiating surface for thermal capacity. Vertical Units are also available, and are equipped with "dry well", which keeps oil from leaking at low speed shaft.

Hundreds of Philadelphia Spiral-Bevel Helical Units are used throughout Industry, driving Paper Mill Machinery, Conveyors, Blowers, Fans, Machine Tools.

Philadelphia Spiral-Bevel Reducers may be had in Horizontal or Vertical Types; Single, Double or Triple Reduction types, to meet every possible requirement.

Send for complete Catalog #SB-57, which describes all types of Horizontal and Vertical Spiral-Bevel Helical Units.

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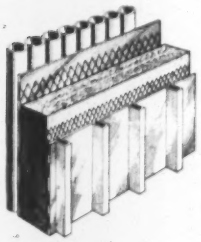

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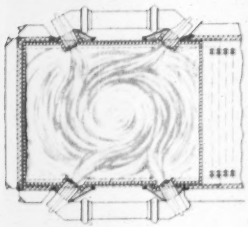

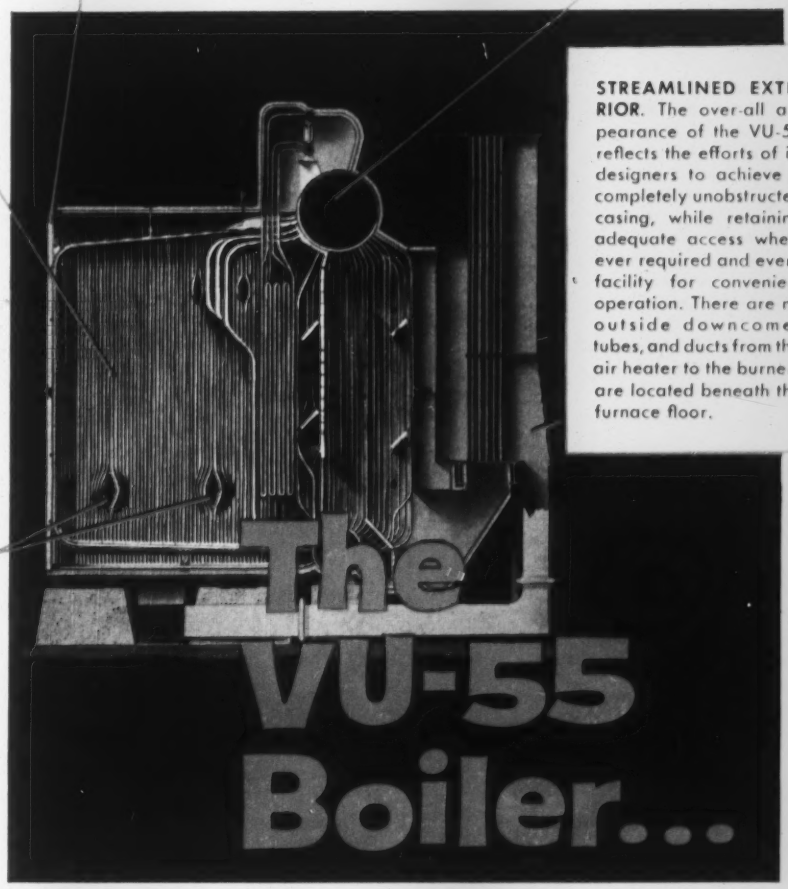

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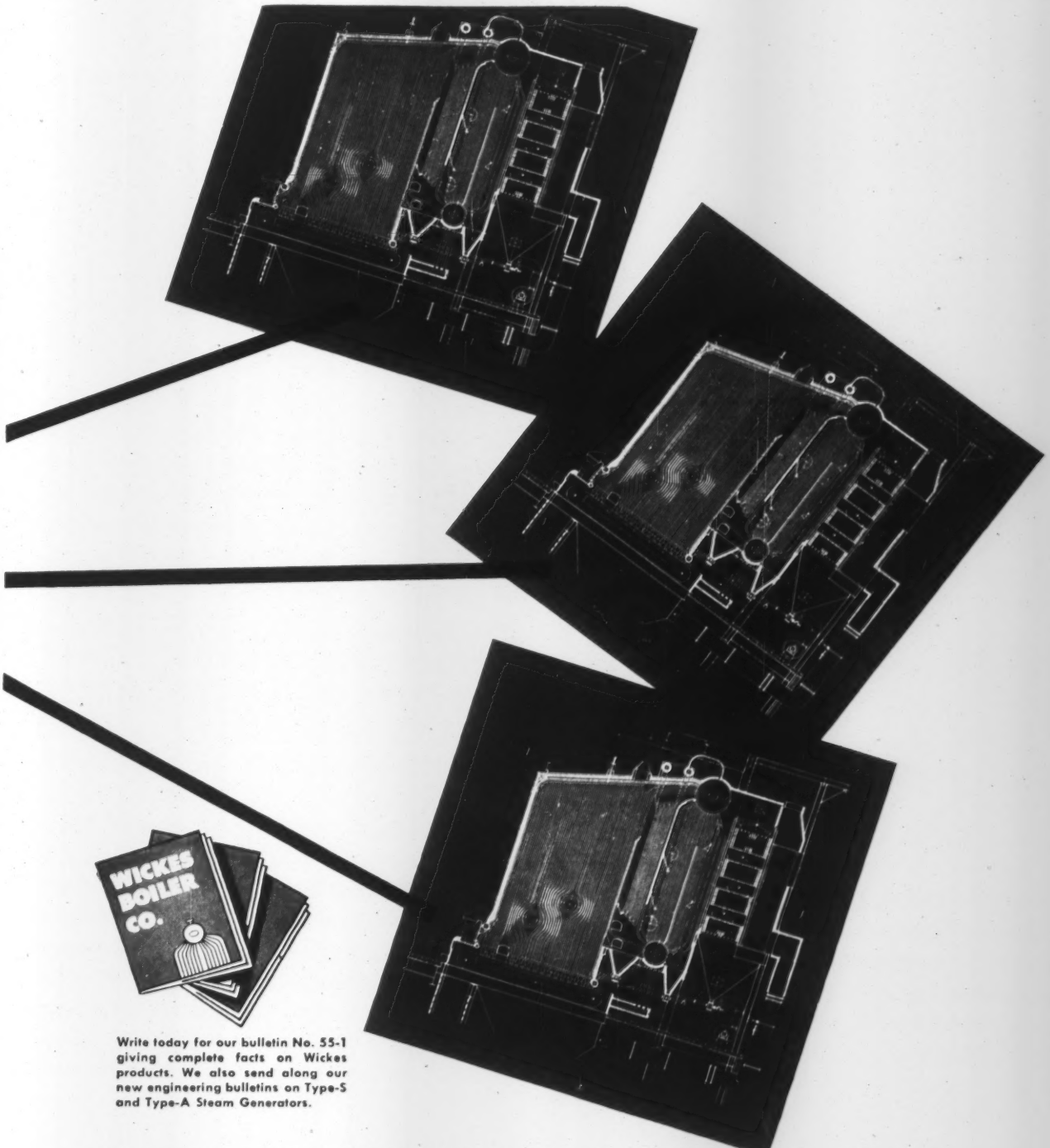

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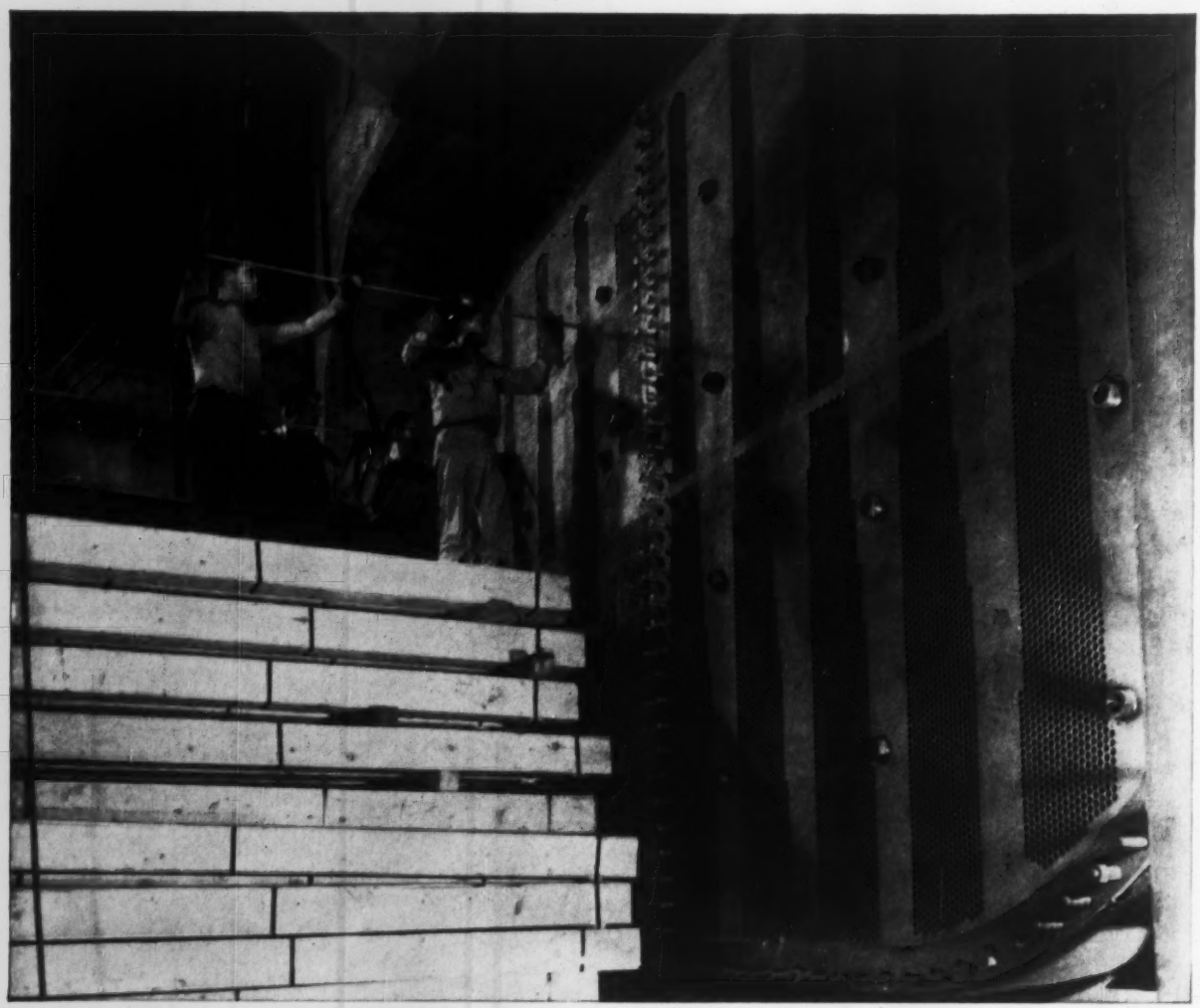

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Saves over 50% on tube costs, reports excellent service

This 105,000 sq ft surface condenser at Wisconsin Electric's No. 3 power unit, Oak Creek, Wisconsin, is the result of more than four years of tests with ALCOA® Aluminum Heat Exchanger Tubes. It is believed to be the first utility company surface condenser of its size to be fitted with aluminum tubes. Development work was handled jointly by ALCOA, Allis-Chalmers and Wisconsin Electric engineers.

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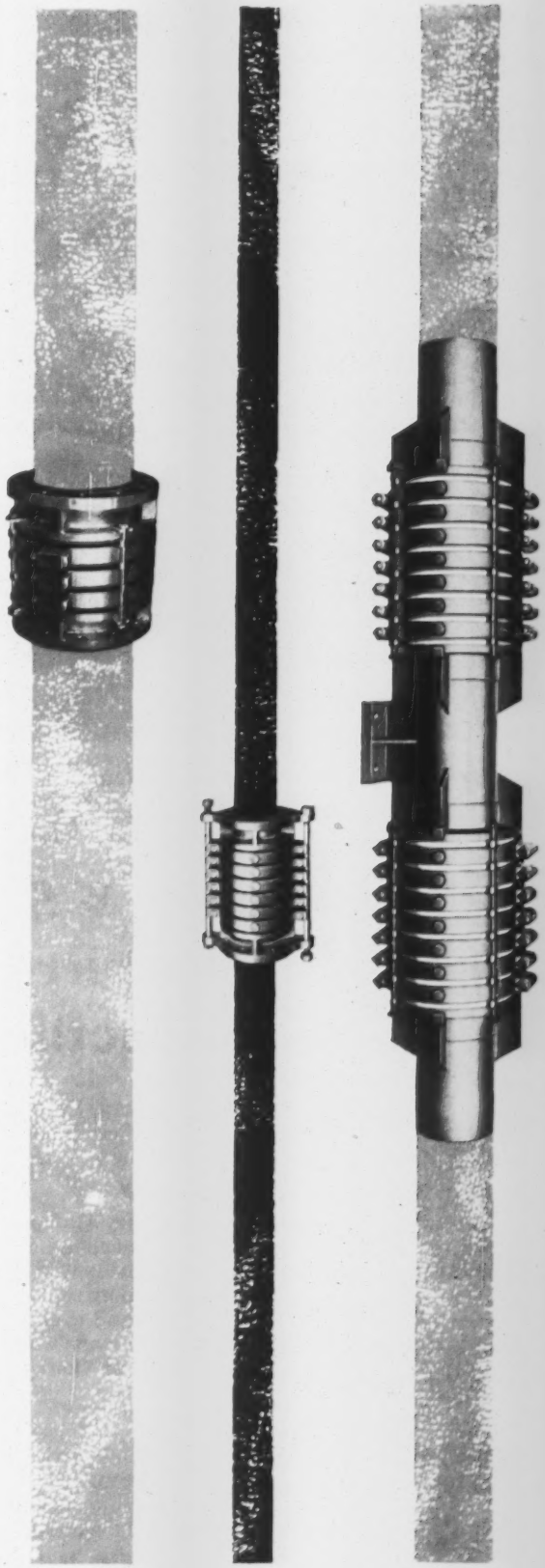

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Volume 79 • Number 3
MARCH 1957

MECHANICAL ENGINEERING

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Lowering the core structure of the EBWR . . .

. . . into place at the Argonne National Laboratory, Lemont, Ill. The Experimental Boiling Water Reactor, now in operation, is the first of the five original projects in the AEC civilian power reactor development program launched in 1954 to reach full power operation. Rated at 20,000 kw of heat and 5000 kw of electricity, the reactor will serve to evaluate possibilities for commercial application of this type of reactor. For further details of the EBWR, see page 268.

Volume 79 • Number 3

MARCH 1957

MECHANICAL ENGINEERING

George A. Stetson, *Editor Emeritus*
J. J. Jaklitsch, *Editor*

Nuclear Engineering

It is appropriate that this issue of Mechanical Engineering be devoted to nuclear engineering, coinciding as it does with the 1957 Nuclear Congress which is being held March 11 to 15 in Philadelphia, Pa. The articles which make up this issue are, in the main, based on papers presented at ASME meetings but include papers from other sources too and should prove both interesting and informative to mechanical engineers. Moreover, they serve to point up that progress in the field of nuclear engineering is moving along at an unprecedented rate of speed.

That ASME is keeping pace in this field, as a service to its members, is clearly evidenced by the first progress report on nuclear engineering, prepared by the Nuclear Engineering Division, which leads off this issue. The report covers power production and its application to the generation of electrical energy; propulsion systems for land, sea, and air; and the application of radiation sources for industrial purposes. Another article describes the features of six nuclear power stations and how they will be applied commercially to the production of electric power. All five of the reactor types selected by the Atomic Energy Commission in 1954 are represented. Other papers cover reactor designs, standards, safety, radiation-hazard control, and even the possibility of putting the atom to work as a power source for a locomotive.

The Nuclear Engineering Division was established by ASME on Nov. 28, 1955, and is the direct outgrowth of the Nuclear Energy Application Committee which was organized less than six months after Hiroshima. The function of the Committee was "to stimulate and develop a continuing program of Society activity dealing with the application of nuclear energy." This the Committee did expeditiously.

Perhaps its outstanding activity was the glossary, a compilation of terminology applicable to nuclear science and engineering. The glossary consists of nine sections, each related to areas of scientific activity.

The Division, since it was formed in 1955, has been extremely active. Besides its contributions to the programs of ASME, the Division participated in the first EJC Nuclear Engineering and Science Congress, held in Cleveland, Ohio, in December, 1955. Again in the Congress being held this month, the Division is contributing greatly to the technical program a program which, by the way, will deal with such topics as establishing safe limits for human exposure to radiation activity, production of nuclear fuel, design and construction of atomic installations, use of isotopes in industry, and many others.

According to Joseph W. Barker, a past-president and Fellow of ASME, and current president of Engineers Joint Council, which is co-ordinating the Congress program, the large number and wide range of interests of participating groups are an indication of the extent to which the field of nuclear energy cuts across traditional fields of specialization.

It may be, therefore, that engineers in areas other than nuclear will find something interesting and useful in this issue of Mechanical Engineering and at the Congress. There are so many possibilities that lie over the nuclear horizon that engineers would be remiss if they overlooked them.

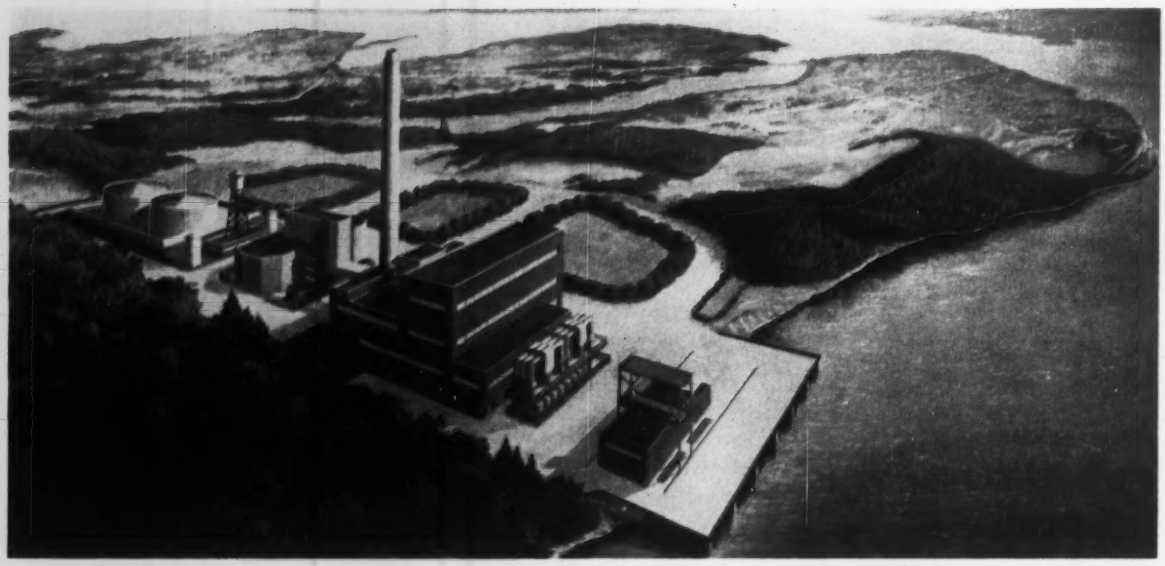
EBWR in Operation

Nuclear engineering also took a front seat on February 9, when the first nuclear power system in the United States, designed and built solely for experimentation in the generation of electric power, was formally placed in operation at Argonne National Laboratory of the Atomic Energy Commission. See page 268 in this issue for further details.

This 5000-kw Experimental Boiling Water Reactor (EBWR) is the first of the original five reactor projects in the AEC civilian power reactor development program launched in 1954 to be completed and to generate electricity.

In the EBWR power system steam is generated within the reactor vessel and piped directly to a turbine without intermediate heat exchangers. Water thus serves as moderator and as coolant to remove heat from the reactor for useful work.

It is expected that the plant will meet the major portions of the electricity requirements of the laboratory. The EBWR will also be used to further studies of boiling reactors and to evaluate possibilities for large-scale power production. So, while the plant is experimental and therefore none of its electrical output will be sold commercially, the operation of this plant marks a significant step toward obtaining useful power from the atom.



Indian Point nuclear steam-electric generating station being constructed by the Consolidated Edison Company of New York on the east bank of the Hudson River about 24 miles north of New York, N. Y. The pressurized-water converter-type reactor will be the first commercial unit to use thorium as the fertile material to supplement the base fuel, uranium-235. Saturated steam leaving the reactor will be superheated in separate oil-fired units for a total output of 236,000 kw of electric energy, with the total cost of the plant estimated at $55 million. See also "Nuclear Power Plants" in this issue.

Nuclear Engineering—Where Do We Stand?

By R. G. Folsom[1] and H. A. Ohlgren[2]

The University of Michigan, Ann Arbor, Mich.

Many areas of nuclear engineering are of direct concern to the mechanical engineer. This brief review is limited to those subjects more directly concerned with power production and its application to the generation of electrical energy: propulsion systems for sea, air, and land; controlled thermonuclear power; and the application of radiation sources for industrial purposes.

The speed at which atomic-energy applications will advance depends on the extent of public understanding, availability of qualified personnel, adequate facilities, and a maximum of unclassified information available for use. Nuclear engineering has much in common with other fields of engineering with respect to the present acute shortage of engineers and scientists. A sound solution to the question of government and private responsibility for atomic insurance is also needed.

It has been recommended that the United States provide other nations with nuclear fuels, technical information, and financial assistance for the development of atomic power and industrial uses of atomic energy. In the spirit of the 1954 Act and of subsequent developments, it has been suggested that further attention be given to the ownership question of special nuclear materials which now rests in the Federal Government. Further clarification of patent provisions is necessary to insure maximum industrial participation in peacetime developments.

Economic nuclear power from fission is largely dependent on the cost and performance of the materials comprising various components of a reactor system. Improvements in the production of presently known materials have significant bearing upon capital investments. Developments of new materials, which permit operation of a nuclear reactor and its associated power-plant equipment at high temperatures, will improve efficiencies of heat cycles and have material influence on costs of power production.

[1] Director, Engineering Research Institute, and professor of mechanical engineering. Mem. ASME.

[2] Professor of chemical engineering; director, College of Engineering Industry Program. Mem. ASME.

Numbers in parentheses refer to Bibliography at end of paper.

Based on a progress report contributed by the Nuclear Engineering Division of The American Society of Mechanical Engineers.

Fuel Material

Uranium-235 is the only material known to man which exists in sufficient quantities in nature to be of practical importance in a self-sustaining fission process. It occurs in uranium ores to the extent of about 0.71 per cent of the total uranium content. With our present-day technology, all nuclear reactors, with the exception of natural uranium reactors, require start-up with the fissionable isotope U-235. By proper arrangement of fuels which fission with materials that capture neutrons, such as U-238 and thorium-233, it becomes possible to produce in a reactor two other materials—plutonium-239 and U-233—which will fission in the ranges of energies considered presently practicable.

The ore deposits which contain uranium are usually of secondary sedimentary nature, lying between beds of sandstone. Large-scale mining techniques are being adapted to the production of uranium ores and present stockpiles indicate large reserves of uranium as a potential source of energy. The Office of Operations Analysis (1) has estimated the future uranium ore requirements that would result from an expanding nuclear power industry in this country. These estimates indicate that the average annual ore rate required for the period from 1960 to 1975 can vary from a few hundred tons to 19,000 short tons of U_3O_8 per year and that the 1975 procurement rate range varies from 6000 to 90,000 short tons.

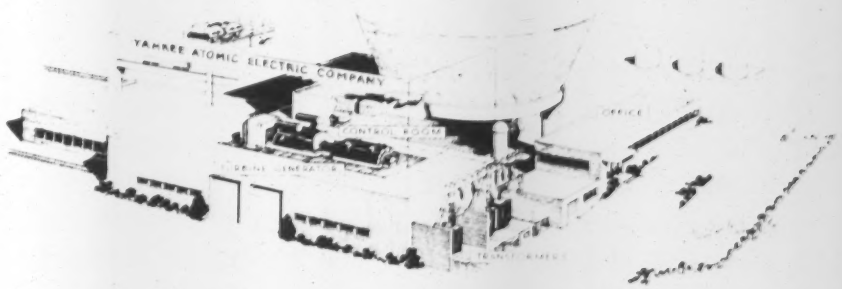
Palmer Putnam in his book (2) estimates that the total amount of uranium and thorium in the earth's crust to a depth of three miles is 10^{12} tons. It might be possible to develop methods for open mining and extraction so that about 10,000,000 tons of uranium and thorium may ultimately be competitive with fossil fuels. If this is the case and if a completely integrated fuels cycles program for nuclear power reactors is ultimately achieved, the energy requirements for a growing world can be satisfied from this source for about six centuries.

Thorium, by some estimates, is more plentiful in the earth's crust than uranium, and is nearly always associated with uranium and the rare earths (3). Production of thorium for nuclear energy has not yet reached significant proportions for the power reactor program.

Preparation of Nuclear Fuels. For technologies in the reasonable future, reactor-fuel assemblages can be solids, liquids, and possibly gases. Most reactors undergoing present-day development utilize solid fuels in the shape of rods, tubes, or flat plates. The fuel elements are fabricated and arranged in such a manner that coolants can extract the fission energy in the form of heat energy. To prevent a given solid-fuel element from being corroded by the coolant and to confine highly radioactive fission products within the fuel elements, cladding materials are normally provided. Examples of cladding materials which have suitable nuclear, thermal, and structural properties for nuclear heat-power plants are aluminum, zirconium, and stainless steel. Stainless steels of various compositions are used as structural materials for heterogeneous fuels for reactors where neutron economies are relatively unimportant. The chemical and physical properties of these stainless steels make them suitable for use in power-producing reactors.

Several promising new types of compact reactor designs have their fuels in liquid form. For liquid fuels, it is possible to formulate homogeneous solutions by several methods. The liquid fuel can be an aqueous solution of a fissionable salt, and the homogeneous fuel can be either a fused salt (melting at high temperatures) in molten form, a molten metal of the fissionable material, or some alloy thereof.

Fertile Materials. Fertile materials may be defined as those materials which are capable of capturing neutrons and decaying radioactively to produce a fissionable material. Two such materials known today are U-238, which upon neutron capture produces plutonium-239, and thorium-232, which upon neutron capture produces U-233. These materials can be purified and fabricated into suitable form, so that when they are used in a re-



The Yankee Atomic Electric Company's plant to be built near Rowe, Mass., is jointly financed by twelve major New England utilities, producing 90 per cent of the area's electrical power. The $35 million pressurized-ordinary-water UO_2-fueled nuclear steam plant will produce 134,000 kw net electrical power.

actor, an optimum utilization of neutrons for various energy ranges can produce additional fissionable fuels while consuming fuel to produce power.

Other Materials Problems. In addition to fuels and fertile materials, nuclear reactors involve many additional materials usages. These include moderators for reducing neutron velocities; coolants for heat removal; neutron reflectors for control of nuclear balances; reactor structural materials for several services; neutron shields, which slow down fast neutrons and absorb thermal neutrons; and biological shields for the protection of personnel by absorption of dangerous radiation.

Nuclear Reactors and Power

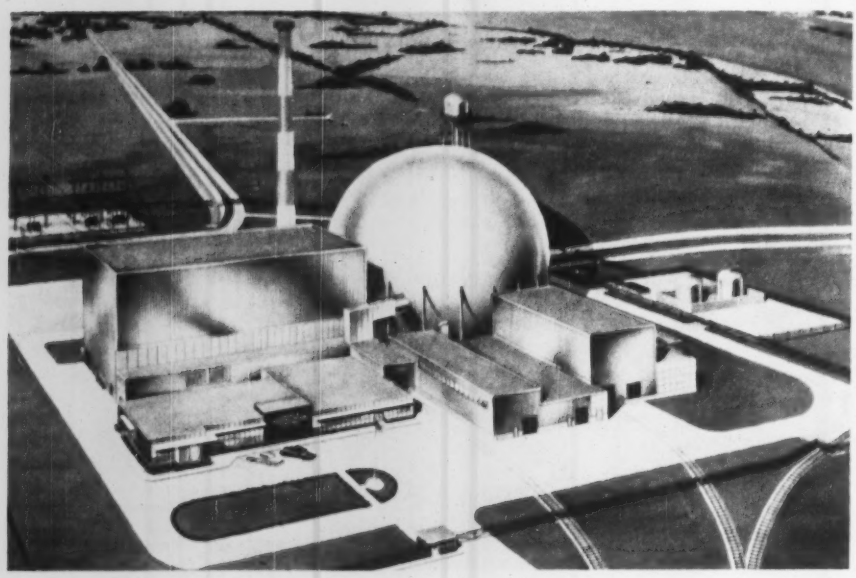
The reactor development program in the United States consists basically of three main parts: (*a*) The development of basic technology; (*b*) the testing of concepts by integrated reactor experiments; (*c*) the power reactor development program.

Status of Reactor Construction (End of 1955). Information on civilian-use reactor experiments and nuclear

Table 1 Civilian-Use Reactor Experiments and Nuclear Power Demonstration Plants Actual or Proposed as of the End of 1955[a]

Type Reactor Experiments	Sponsor	Power level, kilowatts	Estimated cost[b] (millions of dollars) Research and development AEC	Research and development Private	Fabrication and construction AEC	Fabrication and construction Private	Total
Sodium-reactor experiment	AEC-North American Aviation, Inc.	20,000[c]	8.4[d]		5.0[d]		13.4
Experimental boiling-water reactor	AEC (Argonne National Laboratory)	20,000[c]	16.1		3.6		19.7
Homogeneous reactor experiment No. 2	AEC (Oak Ridge National Laboratory)	5,000[c]	37.0		1.8		38.8
Experimental breeder reactor No. 2	AEC (Oak Ridge National Laboratory)	62,500[c]	24.3		15.3		39.6
Organic moderated reactor experiment	AEC (Oak Ridge National Laboratory)		2.0				
Liquid-metal-fueled reactor experiment	AEC (Brookhaven National Laboratory)						
"Demonstration" Plants							
Pressurized-water reactor (in operation 1957)	AEC-Duquesne Light & Power; Westinghouse Electric Co.	60,100,000[e]	59.6		32.25	15.5	107.35
Boiling-water reactor (in operation 1960)	Commonwealth Edison et al.	180,000[e]			0	45.0[f]	45.0
Fast-breeder reactor (in operation 1959)	Detroit Edison et al.-AEC	100,000[e]	3.45		0	55.0[f]	
Pressurized-water reactor (in operation 1959)	Consolidated Edison	140,000[e]			0	55.0[f]	
Aqueous homogeneous reactor (in operation 1962)	Pennsylvania Power & Light et al.-AEC	150,000[e]	(*g*)	(*g*)	(*g*)	(*g*)	(*g*)
Sodium-graphite reactor (in operation 1959)	Consumer's Public Power District of Nebraska et al.-AEC	75,000[e]	10.48		0	16.72[f]	27.2
Pressurized-water reactor (in operation 1958)	Yankee Atomic Electric Co. et al.-AEC	134,000[e]	7.5		0	33.0[f]	40.5

[a] Source, the McKinney Report, vol. 1, p. 32.
[b] Cost estimate covers start as of July, 1953. Earlier costs for civilian-application reactor experiment total $21.3-millions.
[c] Thermal.
[d] Allocation not given. AEC participation in total, $10.55-million; NAA participation, $2.85-million.
[e] Electrical.
[f] Represents total private participation, portion allocated to research and development not given.
[g] Estimate not available.



The $45-million Dresden Nuclear Power Station, a dual-cycle boiling-water UO_2-fueled reactor will be built in Illinois, 50 miles southwest of Chicago. Financing for the 180,000-kw electrical plant is being provided entirely by private industry, principally midwestern utility companies.

power demonstration plants, actual or proposed, as of the end of 1955, is given in Table 1. This list does not include the proposals for small civilian atomic power plants of 5000 to 40,000 kw invited by the AEC in the late fall of 1955.

Table 2 is a listing by reactor type of all known reactor projects throughout the world. These projects are in various stages of completion, from late planning, through construction, and into actual operation.

Pressurized-Water Reactors

Most of the experience to date has been with reactors that utilize water as the means for extracting thermal energy from the fission reaction. In the AEC program for "Demonstration Plants" there are included three reactors which are cooled with either ordinary or heavy water.

(*a*) *Shippingport Reactor* The first of these is the pressurized-water reactor being built by Westinghouse Electric Corporation and Duquesne Light Company at Shippingport, Pa. The Babcock & Wilcox Company and Foster-Wheeler, Ltd. are participating in providing the steam generator. The pressurized-water reactor was selected because it was the only type of reactor then ready for full-scale construction. The basic objective of the Shippingport Reactor is to demonstrate the reliable production of electrical energy. It is expected that valuable knowledge concerning costs for reactor fuels and operating procedures will result from this operation. The pressurized reactor for the Shippingport installation has a unit designed to produce 236,000 kw of thermal

Table 2 List of Reactors of Various Types*

Pressurized Water
LITR (Low-Intensity Test Reactor, MTR Mock-Up)
MTR (Materials Testing Reactor)
STR Mark I, II (Submarine Thermal Reactor)
RFT (Russian)
PWR (Pressurized-Water Reactor)
SFR (Submarine Fleet Reactor)
LSR (Large Ship Reactor)
WTR (Westinghouse Test Reactor)
ETR (Engineering Test Reactor)
TRR (Thermal Research Reactor, Russian)
Yankee Atomic Electric
APPR (Army Package Power Reactor)
Consolidated Edison (+96 Mw C. F. Sup. Ht.)
SAR (Submarine Advanced Reactor)
University of Florida

Boiling Water
BER I (Boiling Experimental Reactor, Borax I, Destroyed)
BER II (Boiling Experimental Reactor, Borax II, Rebuilt as III)
BER III (Boiling Experimental Reactor, Borax III)
EBWR (Experimental Boiling-Water Reactor)
Rural Co-operative Power Assoc., Minn. (+4 Mw C.F. Sup. Ht.)
Nuclear Power Group (Dual-Cycle)

Swimming Pool
BSR (Bulk Shielding Reactor)
Convair Research Reactor
TSR (Tower Shielding Reactor)
Pennsylvania State University
Geneva Conference Reactor (Swiss Research)
University of Michigan
Naval Research Laboratory
American Machine and Foundry
Battelle Memorial Institute
Livermore Laboratory (LPTR)
ORR (Oak Ridge Research Reactor)
Omega West
Watertown Arsenal
Washington State
Trombay (Indian)

Homogeneous
LOPO (Low Power Water Boiler)
HYPO (High Power Water Boiler)
SUPO (Super Power Water Boiler)
HRE (Homogeneous Reactor Experiment, Dismantled)
NAA (North American Aviation)
NCSR (North Carolina State Reactor)
LAPR (Los Alamos Power Reactor)
HRT-1 (Homogeneous Reactor Test 1) (HRE No. 2)
Armour Research Foundation
Gamma Corp.
UCLA Medical
PAR (Pennsylvania Advanced Reactor)

Heavy Water
CP-3 (Chicago Pile 3, modified to CP-3')
ZEEP (Zero Energy Experimental Pile, Canadian)
NRX (National Research Experimental Reactor, Canadian)

Heavy Water (cont.)
ZOE (French)
Russian Research
CP-3' (Chicago Pile 3')
JEEP (Norwegian-Netherlands)
SACLAY (French P-2)
CP-5 (Chicago Pile 5)
Savannah River (five reactors)
Swedish
DIMPLE (Deuterium Moderated Pile, Low Energy, British)
Harwell Research (British)
CISE (Italian)
NRU (Canadian)
Australian Research
NPD (Nuclear Power Demonstration, Canadian)
Brookhaven Medical
Swiss Research Reactor
Norwegian Power (Boiling)
Massachusetts Institute of Technology

Graphite
CP-1 (Chicago Pile 1, rebuilt as CP-2)
CP-2 (Chicago Pile 2)
X-10 (Oak Ridge X-10 Area Reactor)
Hanford 305 Test Reactor
Hanford (eight reactors)
GLEEP (Graphite Low-Energy Experimental Pile, British)
BEPO (British Experimental Pile O)
BNL (Brookhaven National Laboratory)
TTR (Thermal Test Reactor)
RPT (Reactor for Physical and Tech. Investigations, Russian)
Sellafield (British Production, two reactors)
APS-1 (Atomic Power Station 1, Russian)
RBI (Belgian)
G-1 (French Production)
Russian Power (two APS-1 Type Reactors)
G-2 (French Production)
British Power (two Reactors, 25 elec. Mw each)
West German

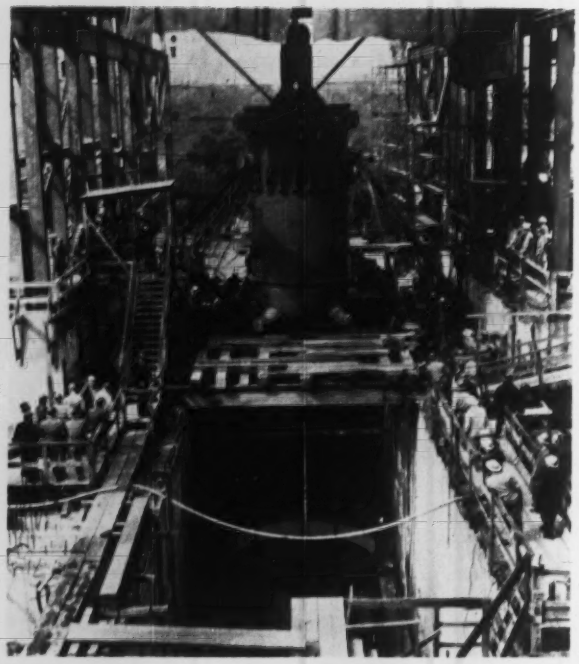
Sodium Graphite
SRE (Sodium Reactor Experiment)
CPPDC (Consumers Public Power District of Columbia)

Liquid-Metal Cooled
Los Alamos Fast (Clementine, Dismantled)
Sir Mark A, B (Sodium Intermediate Reactor)
ARE (Aircraft Reactor Experiment)

Liquid Fuel
LMFR (Liquid-Metal-Fueled Reactor)

Fast Breeder
EBR-1 (Experimental Breeder Reactor 1, CP-4)
Zephyr (British Fast-Breeder Prototype)
British Fast Power Breeder
EBR-2 (Experimental Breeder Reactor 2)
APDA (Atomic Power Development Associates)

* Courtesy of Raytheon Manufacturing Company, Waltham, Mass., "Nuclear Reactor Data," November 15, 1955



Lowering the Shippingport reactor vessel built by Combustion Engineering, Inc., into place, Oct. 10, 1956. The vessel is the heaviest single component for America's first full-scale 60,000-kw commercial nuclear plant. Duquesne Light Company will operate the plant which is being built by Westinghouse Electric Corporation about 25 airline miles from Pittsburgh.

power with an electrical gross generating capacity of 100,000 kw. The reactor uses as fuel 12 tons of natural uranium and 52 kilograms of fuel enriched to about 90 per cent of U-235. The moderator and coolant are ordinary water; it is expected that the average coolant temperature will be 540 F and produce steam at 585 psig saturated. Present estimates indicate that the cost of the reactor, excluding research and development, fuel-element fabrication, and charges for nuclear materials, will approach $370 per kilowatt of installed capacity.

Many safety precautions have been taken to insure reliable operation in a concentrated population area. Other commercial reactors described on pages 233–247 of this issue are:

(*b*) *Yankee Atomic Electric Company* Another type of pressurized-water reactor is the one being developed by the Yankee Atomic Electric Co. for installation in western Massachusetts.

(*c*) *Consolidated Edison Company* A third type of pressurized-water reactor is being developed by Consolidated Edison Company for installation at Indian Point.

(*d*) *Boiling-Water Reactor* The Commonwealth Edison Company, associated with the General Electric Company, is planning the installation of the Dresden Nuclear Power Station, a boiling-water reactor.

(*e*) *Fast-Breeder Reactor* The Power Reactor Development Company and Atomic Power Development Associates, Inc., are developing a fast-breeder reactor, the Enrico Fermi Atomic Power Plant, for installation and construction in The Detroit Edison service area.

(*f*) *Aqueous Homogeneous Reactor* The Westinghouse Electric Corporation and the Pennsylvania Power and Light Company are planning an aqueous homogeneous reactor.

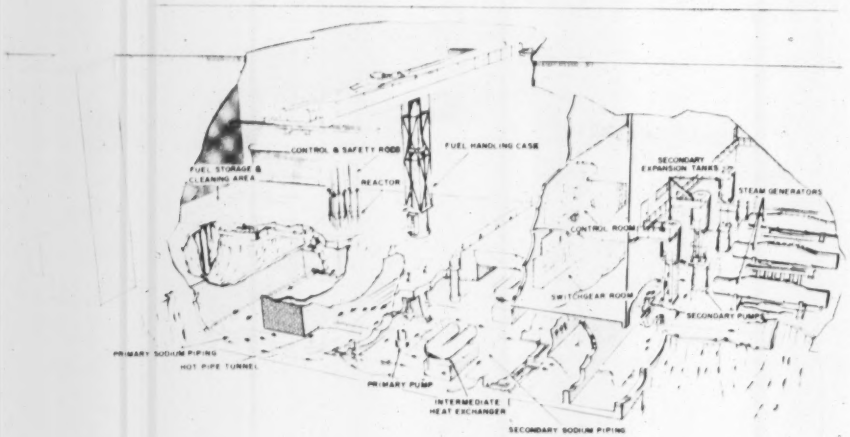
(*g*) *Sodium-Graphite Reactor* The Consumers Public Power District of Nebraska is planning the installation of a sodium-graphite type of reactor, which has been developed largely by North American Aviation, Inc.

In addition to these commercial plants another type is in the experimental stage:

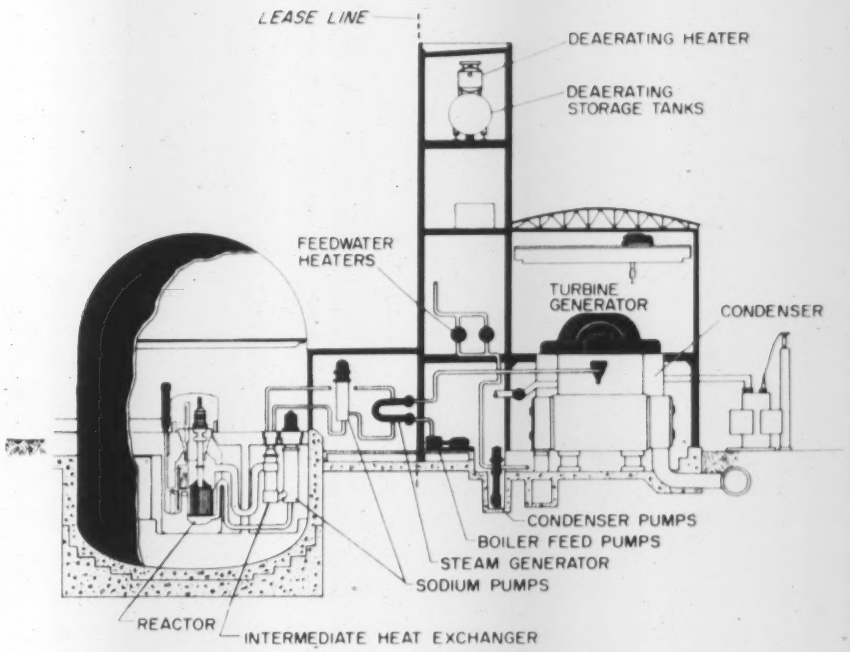
Liquid-Metal-Fueled Reactor. A liquid-metal-fueled reactor, termed LMFR, is one in which the uranium is dissolved in liquid bismuth metal. Basic research and development for this reactor type have been done at the Brookhaven National Laboratory. The Atomic Energy Commission has recently awarded to the Babcock & Wilcox Company a contract to install a liquid-metal-fueled reactor experiment.

Projected Power-Demonstration Reactor Projects

In September, 1955, the Atomic Energy Commission invited proposals from industry for small power-demonstration reactor projects with electric-generating capacities from 5000 to 40,000 kw. The seven proposals re-



The proposed 75,000-kw Sodium Graphite Nuclear Power Plant for the Consumers Public Power District of Nebraska is essentially an enlarged commercial version of the experimental 20,000-kw thermal pilot reactor built jointly by North American Aviation, Inc., and the AEC in the Santa Susana Mountains near Canoga Park, Calif.



The Enrico Fermi Nuclear Power Plant near Monroe, Mich., will use a liquid-metal-cooled, fast-neutron breeder reactor and an 1800-rpm turbine generator to produce 156,000 kw of electricity. The $54-million project is jointly financed by two nonprofit membership corporations, and The Detroit Edison Company will construct the electric-generating facilities.

ceived by the Atomic Energy Commission are indicated in Table 3.

Table 3 Proposed Power-Demonstration Reactors

Organization	Type of Reactor	Kw Electrical Capacity	Scheduled for Operation
University of Florida	Pressurized light water	2,000	1959
Wolverine Elec. Corp., Foster-Wheeler, and Worthington Corp.	Aqueous homogeneous	10,000	
Chugach Electric, Alaska, and Nuclear Dev. Corp., White Plains, N. Y.	Sodium-cooled heavy-water-moderated	10,000	1961
City of Piqua, O'hio	Organic moderated	12,500	1960
City of Holyoke, Mass., and Ford Instrument	Gas-cooled (closed-cycle gas turbine)	15,000	
Rural Co-op. Power Assoc. and AMF	Boiling light water	22,000	1960
City of Orlando, Fla.	Light-metal-fueled	40,000	1960

Nuclear Power Reactors for Propulsion

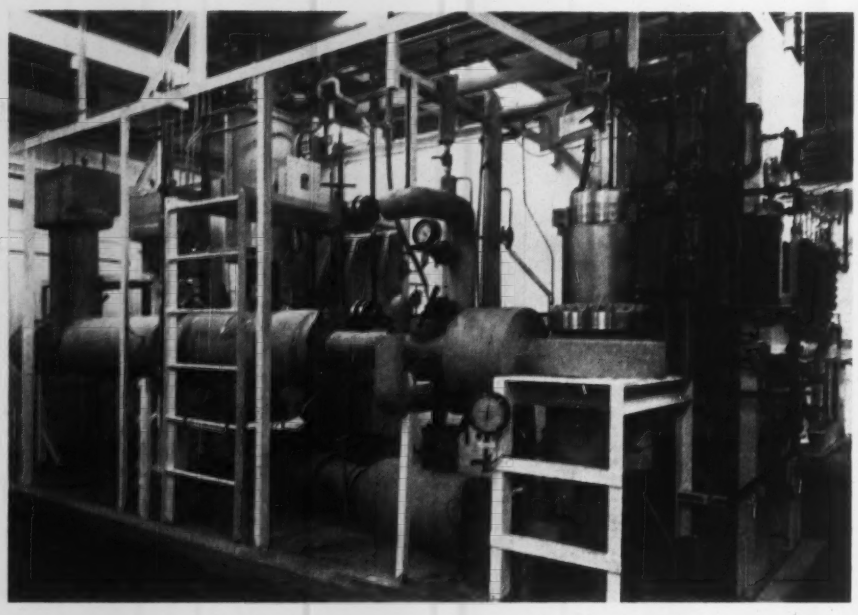
Over the past five years much has been published on the use of nuclear reactors for propulsion. Possibilities for applying nuclear energy to propulsion were recognized early in the atomic-energy program. To date, actual work in the field has been limited to military applications. The Navy and the Air Force are engaged in extensive research and development programs directed toward atomic-powered submarines, surface vessels, and aircraft (4). The Joint Committee on Atomic Energy reports that nuclear energy can become a significant source of power for commercial shipping within the next ten to fifteen years. The actual rate of development is dependent on (*a*) the relative competitive position of nuclear power as it is determined through experience, and (*b*) the basic governmental decisions concerning the requirements for atomic propulsion in the American merchant fleet to further the program for application of nuclear reactors to commercial maritime vessels with atomic engines.

One of the first applications to prove the technical feasibility of atomic energy for propulsion was the successful operation of the *USS Nautilus*. The pressurized-water-type nuclear reactor and propulsion plant for this submarine have been described in several places (5-7).

Atomic propulsion of aircraft appears to be technically feasible. Major problems have yet to be solved before nuclear-powered aircraft will become economically feasible for commercial aviation. According to the McKinney Report commercial aviation with nuclear-heat engines is likely in the next 15 to 20 years.

The significantly unique advantage for the application of nuclear energy to the propulsion of commercial-type aircraft is a flight range unlimited by fuel tankage and the resulting freedom from a system of overseas refueling airfields and a reduction of supply problems associated with the need for fuel stops. Some of the disadvantages for nuclear aircraft lie in the problem of protective shielding. A very substantial amount of shielding would be required to limit radiation dosages to acceptable tolerances for passenger traffic. The shield weight is highly concentrated and necessitates a conventional aircraft structure to be redesigned to accommodate such high specific loads.

The relative economics of conventional chemically fueled aircraft and nuclear-powered aircraft depend on the range of travel, with nuclear power definitely having



The Pennsylvania Advanced Reactor Project is a major development effort, still in the laboratory stage, and jointly sponsored by Westinghouse Electric Corporation and the Pennsylvania Power & Light Company. Experimental and analytical studies are being conducted for an aqueous homogeneous reactor plant with an electrical output of 150,000 kw to be in operation in eastern Pennsylvania by 1962.

the advantage for long flights. In nuclear aircraft operation, consideration must be given to (*a*) dual runways on flight take-offs and landings in the event of an accident releasing radiation; (*b*) the location of engine stations in remotely operated shielded areas for removal of fuel and decontamination; (*c*) the installation of remotely operated maintenance and nuclear-fuel-handling operations in properly designed buildings; (*d*) provision for the disposal of radioactive decontaminated materials; (*e*) special types of vehicles and ground-support equipment for proper attention to craft and crew.

Nuclear propulsion for locomotives is technically feasible on the basis of present-day technologies. Future nuclear locomotives would require the same general dimensional and weight characteristics as present-day locomotives. The probable shaft-horse-power output for a nuclear locomotive lies between 2000 and 5000 hp with an efficiency of 25 per cent for conversion of heat to mechanical energy. This means that the reactor's heat-generating capacity will be between 8 and 20 megawatts. Much of the nuclear engineering and technology required for nuclear locomotive engineering can be supplied from the basic information required to prove the feasibility and economics of naval and commercial shipping, as well as aircraft. (See pages 266-267 for another engineer's ideas on the nuclear-powered locomotives.)

It can be concluded that the practicality of utilizing nuclear energy for the production of electricity for general use and the propulsion energy for naval vessels and merchant vessels has been established. The desirability of applying nuclear power to aircraft propulsion will be determined from results of extensive development toward this goal. Possible advantages that might accrue from the use of nuclear propulsion for land vehicles are still a subject of much speculation. At the present time there are no advantages favoring nuclear power in terms of available range for most civilian land-transportation purposes.

Controlled Thermonuclear Power

Controlled thermonuclear power has potentialities of foremost significance as a usable energy source. The McKinney Report recommends: "1. That the Commission, within the limitations which national security conditions impose, permit the maximum interplay of scientific and engineering ideas, and develop procedures by which more people can contribute to the controlled thermonuclear program in the United States; and 2. That the Commission, in encouraging investments in nuclear fusion power, see to it that investors have sufficient information about the feasibility of nuclear fusion power upon which to base determinations for themselves as to the propriety of their investments and actions" (8).

The Reactions. Thermonuclear reactions whose aim is the controlled energy release from fusion of light nuclei have been pursued by the AEC under the Sherwood program. Actively engaged are groups at Los Alamos, Princeton University, Livermore, Oak Ridge, New York University, and others. Fusion may be defined as the interaction of two light nuclei to form one heavy nucleus with corresponding releases of energy. These reactions require temperatures in the order of hundreds of millions of degrees and must be contained. Certain proposals suggest containing the reaction in electromagnetic fields which may provide insulation effects by proper arrangement. It is conceivable that a fusion reaction could occur without neutron production. Such a reaction could essentially eliminate requirements for shielding.

Russian Thermonuclear Experiments. At Harwell, England, the Russian scientist Kurchatov delivered a dramatic address on April 26, 1956, during his visit to England (9). He told of the thermonuclear investigations being conducted by academician Artsimovich, and discussed conditions for fusion, control of thermonuclear reactors, theory of the "Pinch" effect, gas dis-

(*Continued on page 252*)

Engineering Considerations . . .

. . . in Nuclear Reactor Design

By Alvin M. Weinberg

Director, Oak Ridge National Laboratory, Oak Ridge, Tenn.

THE enormous difficulty of choosing a proper path for reactor development is easily seen by estimating the number of conceivable reactor types. In Table 1 are listed some of the choices which are more or less at the disposal of the reactor designer.

The table by no means lists all possible choices; yet, the total number of combinations is $3 \times 2 \times 3 \times 5 \times 2 \times 5 = 900$ possible reactors! Of course not all of these are sensible; for example, a fast reactor could hardly be cooled with H_2O. Even so, there are probably at least 100 combinations which are not obviously unfeasible. The central issue in reactor development is to trace out of this welter of possibilities the dozen or so which are most likely to succeed.

Table 1 Choices to Be Made in Reactor Design

Fuel	Fertile material	Neutron energy	Coolant	Geometry	Moderator
U-233	Thorium	Fast	Gas	Heterogeneous	H_2O
U-235	Uranium	Resonance	Liquid metal	Homogeneous	D_2O
Pu-239		Slow	H_2O		Be
			D_2O		BeO
			Hydrocarbons		C
			etc.		etc.

Fortunately, the nuclear considerations already outlined greatly reduce the number of possibilities. The slow-neutron-breeding cycle almost certainly requires U-233-thorium; the fast neutron cycle can use either U-233-thorium or plutonium-239-uranium, but the latter has the nuclear advantage.

There are a few general principles which can be used to reduce further the number of possibilities. These will be discussed, though not in order of importance.

Material Efficiency and Thermal Efficiency

If all else is equal, that reactor plant is best which operates at the highest thermal efficiency. However, since in each reactor there is always held up a significant amount of expensive material—either fissionable material or moderator—and this held-up material represents a continuing expense, it is also important to extract as much energy from a given amount of fuel as possible. The electrical energy extracted per unit amount of fuel or expensive moderator might be called the "material efficiency." In a chain reactor, high material and thermal efficiency leads to low over-all power cost.

As an example, consider a water-moderated U-233-thorium reactor which operates at thermal efficiency of 20 per cent and fuel efficiency of 10,000 kw per kg of U-233 with, say, a liquid-metal-cooled fast reactor which operates at thermal efficiency of 35 per cent but fuel efficiency of only 1000 kw per kg of plutonium-239. The electrical output in the one case is 2000 kw per kg of U-233, in the other case only 350 kw per kg. It is quite possible that such a disparity in material efficiencies could overcome the economic advantage of high breeding gain and high thermal efficiency in the fast system.

The economic use of very expensive heavy water finally depends on the extraordinarily high material efficiencies which it makes possible. For example, because D_2O absorbs so few neutrons, a chain reaction in a solution as dilute as $^1/_2$ gram of U-233 per liter of D_2O is quite possible. By careful attention to external equipment design, a thermal power output of 20 kw per liter of heavy water or 40,000 kw per kg of U-233 in a heavy-water system is conceivable.

The choice between gas and liquid coolants in some measure hangs on this issue of material versus thermal efficiency. For example, the Brookhaven reactor operates at about 30,000 kw with a loading of about 100 tons of natural uranium or a material efficiency of 300 kw per ton of natural uranium. With high-pressure water cooling, this could be increased perhaps tenfold. Thus, although the gas-cooled system may ultimately have a higher thermal efficiency, its material efficiency can hardly match that of the liquid-cooled systems. This fact largely accounts for the absence of gas-cooled systems in the U. S. reactor-development program.

Homogeneous and Heterogeneous Systems

The aqueous-homogeneous system represents a final rationalization of the heterogeneous pressurized-water systems; if the fuel elements are made smaller and smaller they finally culminate in a dispersion or solution, i.e., a homogeneous system.

The advantages of the homogeneous systems—simple chemical processing, good heat transfer, good nuclear control—must be weighed against the manifestly formidable problem of containing the radioactivity and the related problem of corrosion. From the point of view of thermal breeding, U-233-thorium homogeneous systems have considerable advantage over the heterogeneous ones. Certainly the 6 per cent xenon loss is eliminated, and there is a good chance that the remaining

Portion of "Survey of Fuel Cycles and Reactor Types," Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, August, 1955, United Nations, New York, N. Y., Paper P/862 USA, vol. 3, pp. 23-25.

fission-product poisons can be removed before they become serious. The only nuclear advantage the heterogeneous systems have is the higher fast effect. To achieve this, however, requires very close lattice spacing and high U-238 or Th-to-fuel ratio. In a power reactor like Pressurized Water Reactor (PWR) the close packing would make awkward any attempt to segregate coolant and moderator, and this would then lead, in the plutonium system, to the difficulty of low η (Pu-239) at high temperature.

The advantage of the heterogeneous system—relatively secure containment of radioactivity—must be weighed against the likelihood of achieving high burnup before reprocessing. To see the magnitude of this problem consider a highly enriched MTR-type breeder in which a 20 per cent burnup and 25 per cent thermal efficiency is achieved. For every fissionable atom burned, five chemical reprocessings are required. This means that, in order for chemical reprocessing to add less than 2 mills per kwhr to the cost of the electricity, a cost of not more than $2.40 per gram can be allowed for each chemical and metallurgical recycle. As the technology now stands it seems more likely that the chemical costs will reach this low value before the metallurgical costs do. It is basically the belief, that the metallurgical costs if not the chemical ones will always be substantial, that has motivated the whole homogeneous development.

Fast Reactors Versus Thermal Reactors

Since both the U-233-Th and the Pu-239-U cycles can be used as bases for a fast-neutron-breeding cycle, it may not be obvious why there should be any incentive to develop thermal U-233-Th breeders. The main reason of course is that thermal reactors are intrinsically more dilute than are fast reactors; hence the material efficiency of a thermal reactor will almost certainly always exceed the material efficiency of a fast reactor. The example of the MTR-type breeder compared with the fast breeder points up this. It may therefore well turn out that U-233 will generally be burned in thermal neutron reactors even though a somewhat higher breeding gain is attainable in the fast reactor.

The engineering problems of the fast reactors center mostly around the fact that any diluent in the reactor tends to decrease the neutron energy while the high η (Pu-239) accrues only if the neutron energy is kept very high—of the order of several hundred kv. Diluents in a fast breeder are of three kinds: Structural material, coolant, and fertile material. Of the three, the fertile material, having the highest inelastic cross section, is most important in depressing the neutron spectrum. Yet there is strong incentive to have a large proportion of, say, U-238 atoms to Pu-239 atoms since the larger this ratio is, the longer such a reactor would operate before serious radiation damage sets in and reprocessing is required. For example, in some fast breeders a U-238-to-Pu-239 atom ratio of 10:1 is contemplated. If the alloy requires reprocessing after 2 per cent of all its atoms are destroyed, 20 per cent of the Pu-239 could be burned before each recycle. Thus five chemical and metallurgical recycles are required to burn one Pu-239 atom, and the problem of high reprocessing costs must be faced. Of course the large breeding gain in the Pu-239-U-238 system tends to offset the economic effect of the manifold reprocessings.

In much the same way there is a limit to the amount of structural and coolant material which the fast system can tolerate. Fast reactors always suffer from low material efficiency. Whether this deficiency can be balanced by the high breeding ratio it is too early to say.

Will One or Two Reactors Emerge as Unique Choices?

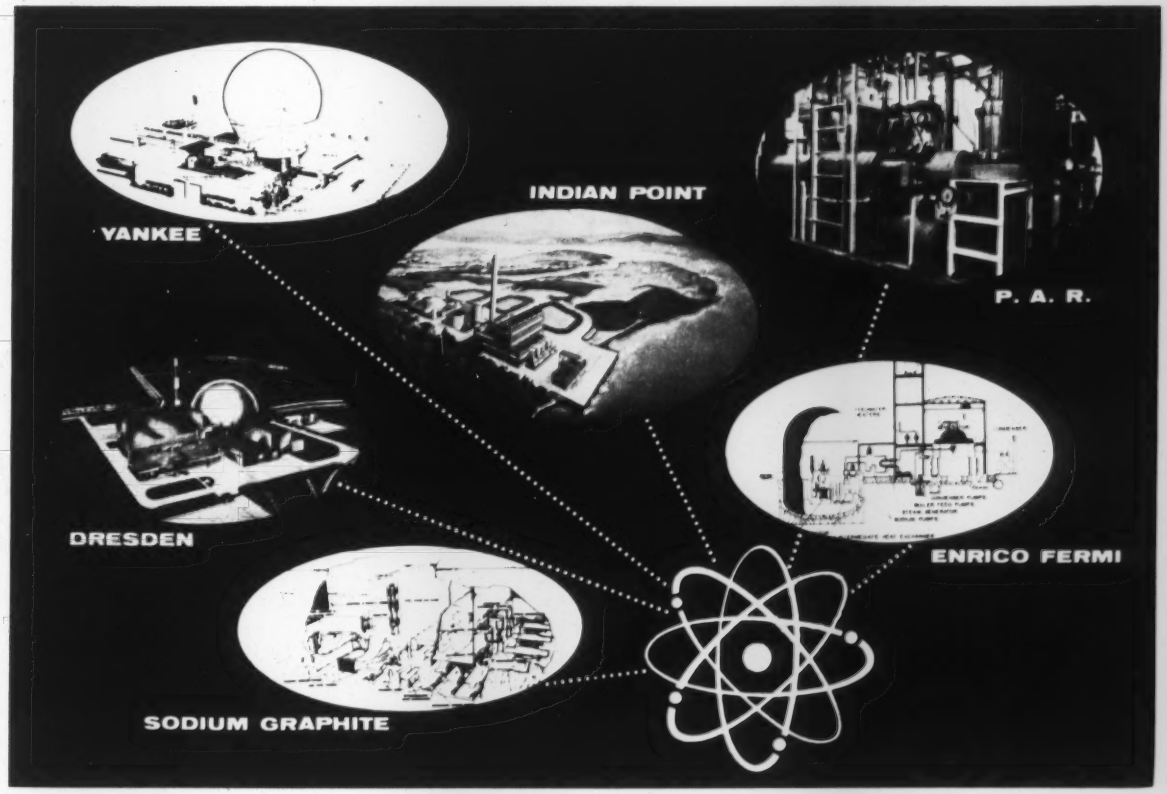
I think every worker in reactor design must have wondered whether, in the long run, any one reactor type will emerge as so distinctly superior to the others that it will render the rest obsolete. The history of hydrocarbon-burning devices suggests that the technology will develop a succession of "most desirable" types; the reciprocating steam engine was followed by the steam turbine—which may ultimately be replaced by the gas turbine. Within each class—say, the steam turbine—there have been a tremendous development and correspondingly high rate of obsolescence; for example, the heat rate on the most modern turbines is less than half the heat rate of turbines only 20 years old.

But the main reason for obsolescence of conventional power-generating devices—low thermal efficiency—will hardly operate to render nuclear power plants obsolete. Rather, nuclear plants ought to be much more like hydroelectric plants; if they have sufficiently low over-all operating costs, and this is a sum of costs determined by thermodynamic efficiency, material efficiency, maintenance, and so forth, then it is at least not obvious why they should become obsolete any more than dams.

Thus in trying to choose the most likely lines of development, the aim will always be to reduce the operating costs. It is perhaps on this account that ingenuity in the method of heat removal as, e.g., in the direct boiling scheme, may prove ultimately to be less significant than ingenuity in fuel handling—that schemes which aim at low operating costs may be more important than schemes aimed at low capital costs.

What I have said refers mostly to the long run. In the meantime, with highly enriched material something of a rarity, it is inevitable that power will be extracted from the natural uranium systems in more or less conventional reactors. Yet once a reactor is constructed with natural uranium fuel rods, there will be strong nuclear incentive, after the first few loadings with ordinary uranium, to switch to the U-233-Th cycle. The strong possibility, even in the heterogeneous system, of making the U-233-Th thermal system self-sustaining will ever be an attractive goal, no matter how plentiful natural uranium may be. Thus it may not really be relevant to argue whether breeders ought to be developed as soon as possible. It seems to me entirely likely that most heterogeneous power reactors which begin their lives as thermal, natural uranium converters will gradually convert to the U-233-Th cycle simply because operation with this fuel is probably independent of raw material.

In any event certainly two nuclear types, the slow cycle based on U-233-Th and the fast cycle based on Pu-239-U will become accepted reactor types. Beyond this—whether the reactors will be homogeneous or heterogeneous, whether the moderator ultimately will be D_2O, beryllium, carbon, or some other, what the coolant will be—these are difficult issues whose outcome no one can foresee. It is of great advantage to our budding technology that it is being pursued—with such little overlapping—in so many different countries, for only out of such diversity in effort will come the answer to the question: "Which reactor type is best?"



Nuclear Power Plants

How various nuclear-reactor systems are being applied commercially to steam generation of electric power

In May, 1954, Mechanical Engineering reported the Atomic Energy Commission's plans to develop five demonstration types of nuclear reactors as part of a five-year program to arrive at an economical solution to the problem of nuclear power.

Nuclear engineering progress has been so rapid that full-scale commercial reactors are now being planned, with several under construction, and most of the rest in the contract or development stages.

All five of the reactor types selected for development by the AEC in 1954 are represented in six papers presented at the 1956 Annual Meeting of The American Society of Mechanical Engineers, and presented here in greatly condensed form.

[1] By G. R. Milne, Mem. ASME, Consolidated Edison Company, New York, N. Y., and F. R. Ward, The Babcock & Wilcox Company, Atomic Energy Division, New York, N. Y. Condensed from ASME Paper No. 56—A-167.

Based on six papers contributed by the Nuclear Engineering and Power Divisions and presented at the Annual Meeting, New York, N. Y., November 25–30, 1956, of The American Society of Mechanical Engineers.

Indian Point Pressurized-Water Reactor[1]

The Consolidated Edison Company of New York plans to construct a nuclear steam-electric generating station on the east bank of the Hudson River about 24 miles north of New York City. The reactor will be a pressurized-water converter type and will be the first commercial unit to use thorium as the fertile material to supplement the base fuel uranium-235. The heat from the reactor would produce 140,000 kw of electric energy if it were not superheated. However, the saturated steam leaving the reactor will be superheated in separate oil-fired units resulting in a total capacity of 236,000 kw and in an appreciable decrease in the cost of the plant per unit of capacity and in a substantial decrease in the plant heat rate. It is expected that the core will be installed in the reactor in the fall of 1959, and full power operation will be attained by May, 1960. The results of the study on superheating are shown in Table 1.

Table 1 Estimated Costs and Capacities of Proposed Nuclear Power Plant at Indian Point, Buchanan, N. Y.

	Total Plant Cost	
	Case 1	Case 2
	Saturated steam	Superheated steam
Steam pressure at boiler, psig	420	420
Steam pressure, turbine inlet, psia	405	355
Steam temperatures, turbine inlet, F	446	1,000
Gross electrical output, kw	140,000	236,000
Turbine plant heat rate, Btu/kwhr	12,900	10,700
Total cost of plant	$45,000,000	$55,000,000
Total plant cost per kw	$ 322	$ 233
Incremental Data on Superheating		
Increased capacity due to superheating, kw		96,000
Increased cost due to superheating		$10,000,000
Cost per kw of increased capacity resulting from superheating		$ 104
Heat rate of incremental capacity due to superheating, Btu/kwhr		7,700
Cost per kw of incremental capacity, adjusted for better heat rate, versus heat rate of best conventional station of 9500 Btu/kwhr		$ 74

Table 2 Estimated Power Production Costs, Indian Point Nuclear Power Plant

Gross reactor capacity—mw—heat	500
Gross electric capacity—reactor	140
superheater	96
Total	736
Net electric capacity—reactor	130
superheater	89
Total	219
Annual net M M W H production (80% LF)	
reactor	910
superheater	623
Total	1533

Annual Costs

	Amount	Cents per kwhr
Fixed charges—$55,000,000 @ 13.5%	$ 7,430,000	0.485
Fuel—nuclear oil	4,650,000	0.303
Operation and maintenance	1,500,000	0.100
Total	13,580,000	0.888

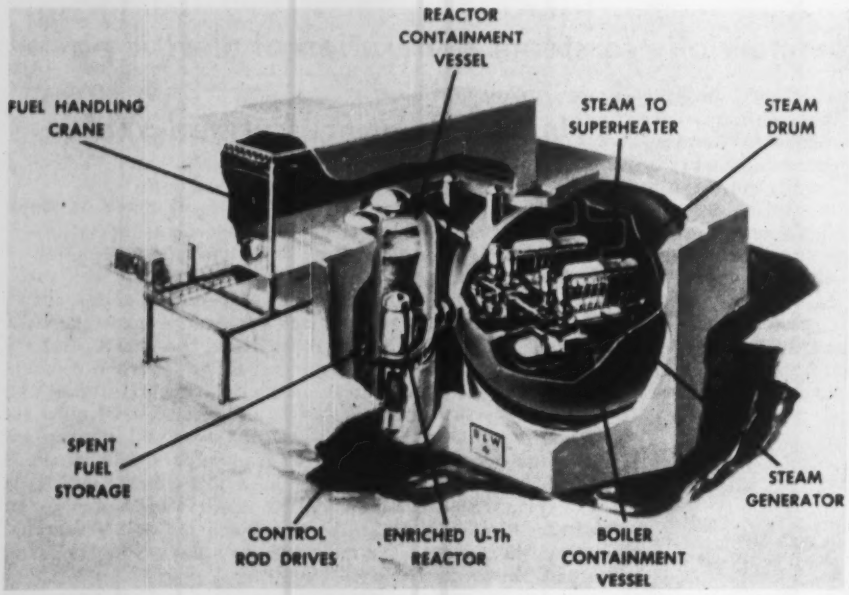
The economics of superheating the saturated steam from the reactor having a temperature of 446 F at the turbine throttle to various temperatures, 860 F, 1000 F, and 1050 F were studied. Only the most economic case is shown in Table 1, namely, that for 1000 F. The steam pressure at the throttle is reduced from 405 psig to 355 psig because of the pressure drop in the superheater and piping.

An examination of Table 1 will show that the addition of superheat to the cycle results in an increase in capacity from 140,000 kw to 236,000 kw and a reduction in cost from $322 per kw for a plant using only nuclear fuel to an average cost of $233 per kw for a combination of a nuclear boiler and separate oil-fired superheaters. Since the rapid growth of the system load makes it necessary to continue building conventional steam-generating units while obtaining experience in building and operating a nuclear unit, the cost of the increased capacity gained by superheating before and after credit for lower heat rate may be compared to a cost of $200 per kw for new conventional generating capacity in New York City. The use of superheat will also reduce the maintenance costs on the turbine as compared to a unit operating on wet steam throughout.

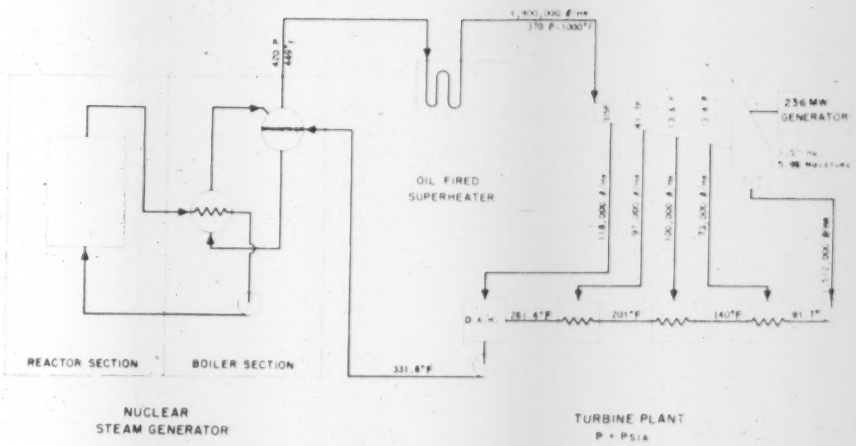
The cost per kwhr of energy produced by the combination nuclear-oil-fired plant is shown in Table 2.

Auxiliary Power Supply. To insure the degree of continuity of auxiliary power supply which is essential to reactor operation, three normal sources will be provided; one from each of the two 138,000-volt transmission lines and a third from the terminals of the main turbogenerator. Furthermore, to provide for the contingency of failure of all three of these auxiliary services, an emergency source will be provided—probably from a small steam-driven turbogenerator.

Operating Features. The reactor will be regulated to provide constant steam pressure in the boiler regardless of the load on the turbogenerator. This avoids the use of a main-line pressure-reducing valve which would other



Nuclear steam generator, Indian Point Plant. The nuclear steam generator comprises chiefly the reactor, the necessary piping and valves, the boilers, the circulating pumps, the pressurizing system, coolant treatment, and make-up systems, the fuel-element changing and discharging equipment, the shielding, the reactor controls and associated instrumentation, and the safety containment vessels. Its maximum design rating is 500,000 kw (heat). The steam produced is saturated at 405 psig.



Heat balance diagram, Indian Point Plant. The feedwater system consists of four stages with three closed feedwater heaters followed by a deaerating-type heater for the removal of oxygen. The heat rate for the steam cycle exclusive of reactor efficiency is 10,700 Btu per net kwhr produced.

wise be necessary if the reactor were controlled for constant reactor temperature. The reactor will also be designed so that load may be increased from 15 per cent to 100 per cent load over the period of a half hour and so that the load may be taken off the unit at the same rate. Operation below 15 per cent of full load is not contemplated because of reactor limitations.

Reactor Design

The reactor is an internal thorium thermal converter fueled initially with highly enriched U-235 and moderated and cooled with pressurized light water. The active portion of the reactor, the core, is a right cylinder about 6 ft in height and about 6 ft in mean diam. The core is made up of over one hundred replaceable fuel elements each of which is square in cross section and contains alternate fuel and fertile plates separated by coolant channels.

The fuel plates consist of uranium-zircaloy core clad with zircaloy, and the fertile plates consist of thorium core clad with zircaloy.

Thorium was chosen as the fertile material on the basis of its structural properties, its compatibility with zircaloy, its low irradiation damage, and its superior ability to supplement the original fuel supply. With the passage of time, an appreciable portion of U-233 produced in the thorium is consumed in situ and the remainder contributes to the reactivity of the core in a favorable way.

The core is surrounded laterally by a 6-in. water reflector and the entire assembly is housed in a thick-walled pressure vessel. Steel thermal shields protect the pressure vessel against structural damage and excessive heating from neutron and gamma flux. A portion of the main coolant flow is diverted to cool the thermal shields and pressure vessel.

With about 55 per cent of the core volume filled with water and an inventory of about 8275 kg of thorium, approximately 275 kg of fully enriched U-235 provide sufficient excess fuel to accommodate the various reactivity changes.

Under normal conditions, 120,000 gpm of coolant water is passed through the reactor. Flow is upward, and single-pass, from four inlet connections in the lower section of pressure vessel to four outlet connections in the upper section of the vessel.

The pressure is maintained at 1500 psia, enough to prevent boiling in the core. The coolant temperature is limited by a maximum fuel-plate surface temperature of 600 F. Mean reactor-water-outlet temperature is 510 F and mean reactor-water-inlet temperature is 480 F.

The average heat flux for full-power operation of a new core is about 169,000 Btu per hr per sq ft. This is reduced somewhat as the production of heat is spread to the thorium plates, and since no more than one third of the core will be replaced at any time, will probably never exceed the initial value.

For proper operation of this reactor, an excess of reactivity over the cold clean core is required in order to compensate the effects of (1) increase in moderator (water) temperature, (2) buildup of fission-product poisons, (3) burnout of fuel and buildup of higher isotopes, and (4) short-time-shutdown buildup of xenon-135. This excess reactivity is balanced out as required by 21 individually driven cross-shaped boron-steel control rods. The effective part of each rod assembly is about $5^1/_2$ ft long. Hydraulic actuators or electromechanical actuators with external drives and buffer seal are under consideration.

Reactor Pressure Vessel and Containment

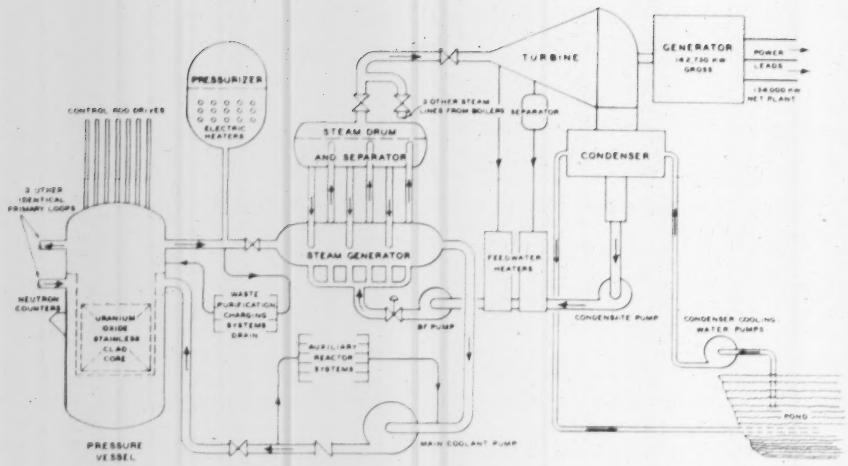
The reactor pressure vessel is a cylindrical shell of carbon steel about 10 ft in diam and about 30 ft high. The inner face of the vessel will be clad with Type 304 stainless steel.

The vessel is set vertically in a containment shell. A skirt-type support permits temperature expansion of the vessel while holding it firmly in position. The vessel will be designed and fabricated in accordance with the ASME Boiler and Pressure Vessel Code for a design pressure of 1800 psia, 550 F.

The containment shell will be filled with demineralized water to a depth of 18 ft above the closure head of the vessel. This water will provide shielding during normal operation of the reactor and will also protect manipulator personnel during fuel-loading and unloading stages.

Primary Coolant System

The primary coolant system consists essentially of four loops operating in parallel, each transferring one quarter



Yankee reactor and steam systems. Heat generated in the reactor is removed by 10^6 lb per hr of water coolant flowing longitudinally in a single pass along the fuel rods, with local boiling but not bulk boiling permissible within the core. At the heat exchangers, an intermediate cycle carries heat to the turbine circuit to prevent the transfer of radioactivity.

of the total power generated by fission in the reactor core to the steam system. Each loop comprises a boiler, two 15,000-gpm pumps with associated check valves, 24-in. Type 304 stainless-steel pipe, and two remotely operated stop valves to permit isolation of the loop. As has been stated, the coolant is demineralized ordinary water under a pressure of 1500 psia.

Fuel Elements

The fuel elements are assemblies of 0.060-in-thick fuel plates and 0.080-in-thick fertile plates spaced alternately to provide 0.100-in. water channels. Individual plates are about $2^1/_2$ in. wide and are assembled in two rows in order to provide a square cross section with a lateral dimension somewhat more than two plate widths. The exact dimensions and total number of assemblies depend upon the final specifications for control-rod positions. All assemblies are of identical dimensions for flexibility in the fuel-loading program.

Shielding

The shielding for the station serves two primary functions: (*a*) Personnel protection during reactor operation; (*b*) personnel protection during fuel reloading.

Up to six ft of ordinary concrete around the containment vessel and part of the reactor service building will be provided to protect personnel in the building and general area of the nuclear steam generator during reactor operation. The radiation level at the exterior of the shield in most areas will be below $2^1/_2$ milliroentgen per hr, but in no place will it be higher than $7^1/_2$ milliroentgen per hr.

The reactor containment vessel, along with the canal above it, holds water to a height of approximately 20 ft above the reactor vessel. This protects personnel from neutron radiation on the crane-bay floor during reactor operation and also protects personnel from the decay gamma radiation during the fuel-reloading periods.

A perimeter fence surrounding the plant is so located as to reduce the radiation level outside of its confines to about $^1/_{10}$ AEC tolerance. This fulfills the New York State regulations concerning radiation protection.

Yankee Pressurized-Water Reactor[2]

Twelve major New England utilities, producing 90 per cent of the area's electrical power, have joined in the financing of Yankee Atomic Electric Company. The company will build a $35-million pressurized-ordinary-water, UO_2-fueled reactor with 134,000-kw net electrical-power output. The major objective is to make the pressurized-water reactor nearly commercially competitive with conventional-type steam plants, without sacrificing any of the inherent safety of this reactor type. An additional $5-million preliminary research and development cost will be borne by the AEC, with any excess over that sum to be financed by Yankee and Westinghouse, one of the contractors, according to an agreed formula.

The final design will be specified at the completion of the Research and Development Program, but the reference design follows. The Yankee reactor is to produce 480,000 kw of heat power for a plant which will generate the 134,000-kw net electrical output. The reactor vessel is made with 8-in-thick 109-in-ID stainless-clad carbon-steel walls. It weighs about 250 tons with head.

The fuel cladding and the structural material of the core are stainless steel. The core contains approximately 60,000 lb of uranium oxide enriched to approximately 2.6 atom per cent in the fissionable isotope uranium-235. The weight of stainless steel in the core is approximately 10,000 lb. The volume ratio of water-to-equivalent uranium metal will be approximately 2.8.

Control is based on control rods for operation and chemical control for shutdown from hot to cold. The control-rod material is nominally a 50 per cent cobalt alloy.

The mechanical design is based on a rod type of fuel element packaged into fuel assemblies which can be loaded separately into the core for fueling purposes and unloaded under water for shielding.

[2] Condensed from "The Yankee Atomic Electric Plant," by Glenn A. Reed, Yankee Atomic Electric Company; Robert J. Creagan, Westinghouse Electric Corporation; and Walter C. Woodman, Stone & Webster Engineering Corporation; ASME Paper No. 56—A-166.

Thermal design considerations are based on 37 × 10^6 lb per hr of water, as the coolant, flowing longitudinally in a single pass along the fuel rods; a temperature limitation in the center of the hottest fuel pellet of 4000 F; and the restriction that there be no bulk boiling in the hottest channel at the operating pressure of 2000 psi. Local boiling (surface boiling of the subcooled liquid) is allowed within the reactor core.

Fuel costs are based on a 10,000-hr core life at full power. This corresponds to an average fuel burnup of 8000-mw days per metric ton of uranium fuel. Calculated fuel costs per net electric kwhr are approximately 3 to 5 mills. This figure includes fabrication of the fuel elements and reprocessing of the irradiated fuel elements, the fuel burn-up charge, the fuel depletion charge, and a plutonium credit as nearly as can be determined in this new and uncertain cost area. This figure also includes the cost of converting the enriched uranium hexafluoride to uranium dioxide powder.

Mechanical Design of Core

The Yankee core approximates in shape a right circular cylinder 74 in. in diam and 100 in. high giving a length-to-diameter ratio of 1:3. The core consists of four substantially identical quadrants containing 19 fuel assemblies each, making a total of 76 fuel assemblies in the complete core. The fuel assemblies are square in cross section and are assembled in a close-packed square lattice.

The 76 individual, replaceable fuel assemblies are held in the core between a lower support and an upper core-support plate. Holes are provided in both support plates for the coolant inlet and discharge nozzles of the separate assemblies.

These support plates have, in addition, 32 cross-shaped slots to allow passage of the 24 cruciform control rods and the 8 cruciform shim elements. The axes of the control rods are parallel to the vertical axis of the core; the control rods are each actuated by a separate mechanism above the core. Reactivity of the core may be increased by lifting the control rods out of the core in a vertical direction.

The core consisting of 76 fuel assemblies is surrounded by a form-fitting baffle which confines the flow within the fuel-bearing zone. Outside the baffle, and surrounding it, there is a core barrel. This is the structural member joining the top and bottom support plates. The water flowing between the form-fitting baffle and the barrel acts as a reflector.

Fuel Assemblies

The approximately $7^1/_2 \times 7^1/_2$-in. fuel assemblies are roughly square in cross section. Each fuel assembly has a total length of approximately 120 in. and a core (or "active") length of 102 in.

The basic element in the fuel assemblies is the 0.3-in-diam and 0.3-in-high fuel pellet, with 340 pellets assembled in a 0.015-in-wall-thickness stainless-steel tube to make a fuel rod having an over-all length of 117 in. and an active fuel length of 102 in.

The fuel rods are assembled on a square lattice with a center-to-center distance of 0.420 in. to make a fuel-rod bundle. Only two fuel-rod bundle designs are used, having 305 and 306 fuel rods, respectively, assembled in a square array, 18 × 18. Rods are omitted from this pattern, as required, to provide slots for the passage of the blades of the cruciform control rods, thereby reducing the number of rods from 324 (the number in a full 18 × 18 array) to the numbers just given (305 and 306).

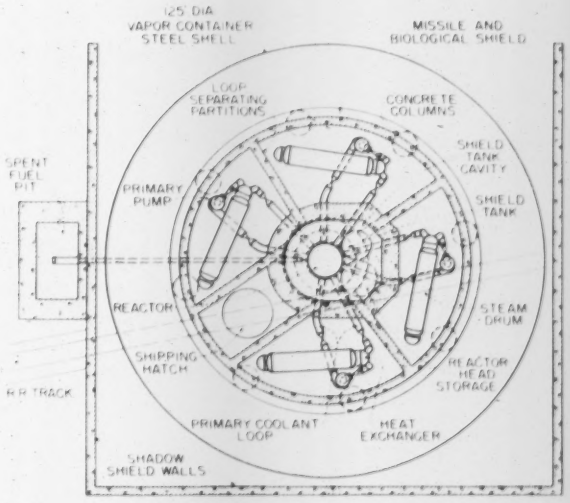
The fuel rods are assembled into fuel assemblies by brazing or welding to provide the proper spacing between rods and to furnish the required structural rigidity to the fuel assembly. Tubular spacers or ferrules, approximately $^3/_4$ in. long, are placed between the fuel rods at intervals of 14 in. along the length of the bundle. The ferrules in adjacent water channels are staggered to minimize the obstruction to the flow of coolant along the fuel rods.

Control

Control of the Yankee plant will probably be so arranged as to keep the average temperature of the reactor constant although other systems are also being investigated.

Control is implemented by using neutron-absorbing control rods during operation and a neutron-absorbing chemical compound dissolved in the primary-loop water for shutting down from hot to cold.

The cruciform control rods, 24 in number, are of the poison type with extensions of low-neutron-absorption cross-section material which will act as guides and prevent the formation of a "water hole" in the core when a poison section is withdrawn. The poison material for the control rods has been specified, norminally, as Haynes-25 alloy. This material produces a control rod with an effectiveness approximately 70 per cent of that of a "black" material, that is, a material which absorbs all neutrons incident upon it. Development of a satisfactory black control rod for the Yankee core is the objective of one of the major Research and Development Programs. The material for the rod extensions is zircaloy-2.



Yankee reactor containment building seen in horizontal cross section. The four identical primary coolant loops radiating from the central reactor are individually shielded to permit partial shutdown for maintenance work. Missile and biological shielding are provided, and a 125-ft-diam steel vapor containment shell will prevent the spread of radioisotopes in case of accident.

In the Yankee core, the number of types of fuel assemblies is limited to two in order to provide maximum flexibility in the interchange of fuel elements within the core during reloading. This results in a core design having 32 cruciform slots of which only 24 are occupied by control rods. The remaining 8 cruciform slots may be used for shim elements. The shim elements may be either a poison or fuel type; that is, the cruciform elements may be made of a nuclear poison material or may be built up of fuel rods. If no reactivity effect from the shim elements is desired, they may be constructed of zircaloy-2. In this case, the nuclear effect of the shim elements would be to eliminate the undesirable neutron-flux peaking which would occur were the water not excluded from the slot. The shim elements also restrict the by-pass coolant flow.

The worth of a central black control rod in the reference core has been calculated. No interaction effects are assumed, and the worth of eccentric rods is assumed to vary as J_0^2 (B r) where J_0 (B r) is the primary mode of the thermal-flux distribution. If cobalt-alloy rods are used, the total worth of 24 rods will be reduced approximately 25 per cent. The chemical shutdown system used is sufficient to control the reactor from hot to cold. The decrease in reactivity due to fuel burnout for two-cycle loading will be about half that for single[5] loading. The solubility of ammonium pentaborate, $(NH_4)_2B_{10}O_{16}$, $5H_2O$ is 9.6 gm per 100 ml of cold water.

Six hundred ppm of natural boron in the coolant is equal to approximately 6 per cent in reactivity.

Thermal and Hydraulic Design

This thermal and hydraulic design of the Yankee reactor was developed on the basis of the following assumptions:

(*a*) Steam conditions at full load at the outlet of the steam generator are 520 psia, 471 F; the log-mean-temperature difference in the steam generator is 31.2 F at full load. Coolant flow of 37×10^6 lb water per hr.

(*b*) Local boiling (surface boiling of the subcooled liquid) but not bulk boiling is permissible within the core.

(*c*) The hot-channel factors must recognize variations in the thermal requirements in the core due to the variations in dimensions, flow distribution, and both normal and perturbed neutron flux.

Dresden Boiling-Water Reactor[3]

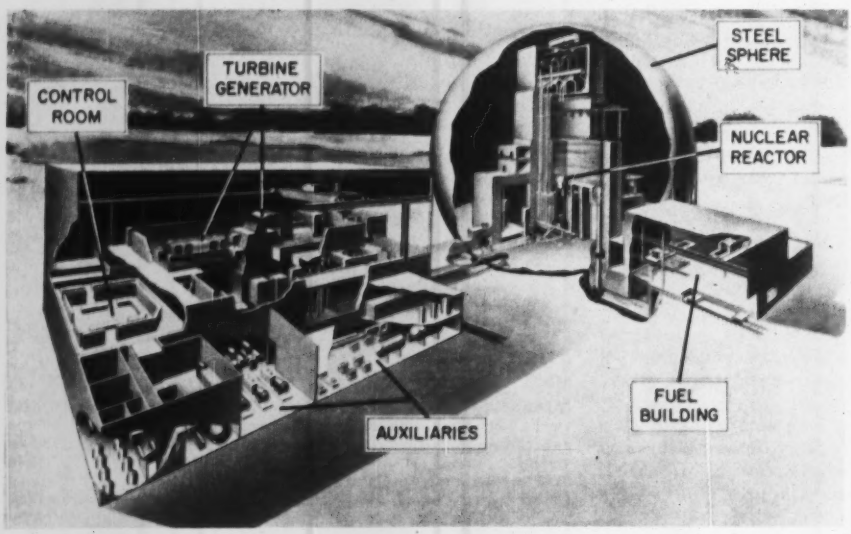
The $45-million Dresden Nuclear Power Station, a dual-cycle boiling-water UO_2-fueled reactor, will be built in Illinois, 50 miles southwest of Chicago, adjacent to the Des Plaines and Kankakee Rivers.

Financing is being provided solely by private industry. The group is composed of: American Gas and Electric, Bechtel Corporation, Central Illinois Light Company, Commonwealth Edison Company, Illinois Power Company, Kansas City Power & Light Company, Pacific Gas & Electric Company, and Union Electric Company of Missouri.

The design of the Dresden Plant is based on a judicious combination of long-established practice and conditions sufficiently advanced to make a substantial contribution to the art. Many of the decisions made in establishing the design are based on a desire to keep it as simple as possible, with a minimum of equipment, and to take advantage of the inherent stability, simplicity, and safety of the dual-cycle boiling-water reactor.

The fundamental design objectives are: 180,000 kw net electrical output at 85 per cent power factor and 75 F condenser cooling water; capability for operation at 60 per cent capacity factor; total energy costs approximately comparable to those of the most efficient plants in the Commonwealth Edison System. Basic criteria were developed after initial studies to guide the design work had been made.

[3] Condensed from "The Dresden Nuclear Power Station," by J. R. Wolcott, V. A. Elliott, Mem. ASME; E. P. Peabody; G. M. Roy; J. L. Schanz, Assoc. Mem. ASME; and G. Sege, all of the Atomic Power Equipment Department, General Electric Company; ASME Paper No. 56—A-169.



Dresden Nuclear Power Station. The 180,000-kw boiling-water reactor and its related components will be contained in a steel sphere 190 ft in diam which will contain contamination in the unlikely event of a major disaster. Adjoining buildings will house the turbine generator and fuel-handling facilities. The major items of equipment in the reactor building are the reactor vessel, the primary-steam drum, secondary-steam generators, the recirculating pumps, and the main biological shielding. The steam-water mixture produced in the reactor vessel flows through the riser pipes to the primary drum which is centrally located approximately 85 ft above the reactor vessel. The downcomers feed two lower headers which in turn supply the pumps and secondary-steam generators.

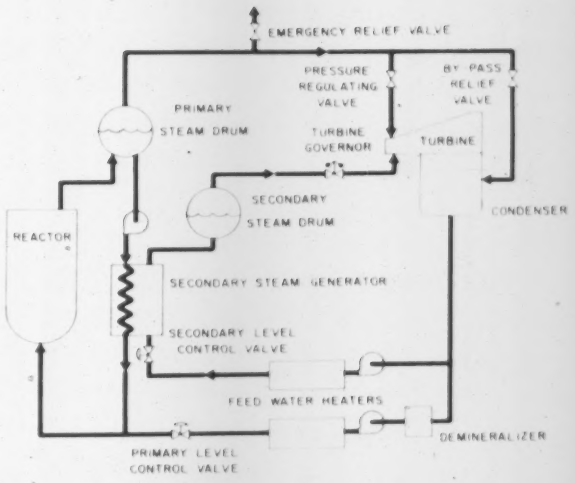
Maximum critical reactor parameters are: (*a*) 300,000 Btu per hr per sq ft maximum fuel element, heat flux; (*b*) 3000 F uranium-oxide fuel temperature; (*c*) 2.5 per cent reactivity compensated by steam voids in the reactor moderator.

The dual-cycle boiling-water reactor was selected as the best solution to these design requirements. The dual-cycle approach is to remove as much energy as possible by boiling in the upper part of the reactor without exceeding the limit of reactivity for good stability. A simplified flow diagram of this cycle is shown. The boiling portion is controlled by the degree of subcooling at the inlet to the reactor.

To accomplish this, the steam-water mixture is sent to a separating drum, and the steam, essentially at reactor pressure, then flows directly to the turbine. The saturated water flows from the drum through heat exchangers where some energy is removed to produce steam at a somewhat lower pressure. This secondary steam is admitted to a lower stage of the turbine. The fraction of energy removed by the heat exchangers controls the temperature of the water returned to the reactor.

As would be expected, the heat rate of the dual cycle is contingent upon the primary steam pressure and the percentage of power which is removed as primary steam. Primary pressures of 600 and 1000 psig were considered. The higher value was selected as fuel savings from a 10 per cent improvement in heat rate outweighed higher capital cost. Surface-temperature limitations of the fuel elements made consideration of higher pressures unfavorable. The net station heat rate for the 1000-psig system is calculated to be 11,893 Btu per kwhr; for the 600-psig system, 13,150 Btu per kwhr.

Existing fabrication and transportation facilities limit the diameter of the vessel containing the nuclear core to slightly over 12 ft for a 1000-psig system. Various mechanical problems make a core length greater than 10 ft undesirable. Balancing these various factors to obtain optimum conditions results in a core approximately 10 ft in diam with an active length of 9 ft and composed of approximately 700 fuel channels.



Simplified flow diagram of the Dresden Nuclear Power Station. The dual-cycle approach is to remove as much energy as possible by boiling in the upper part of the reactor vessel without exceeding the limit of reactivity for good stability. The boiling portion is controlled by the degree of subcooling at the inlet to the reactor. To accomplish this, the steam-water mixture is sent to a separating drum, and the steam, essentially at reactor pressure, then flows from the drum through heat exchangers where some energy is removed to produce steam at a somewhat lower pressure. This secondary steam is admitted to a lower stage of the turbine. The fraction of energy removed by the heat exchangers controls the temperature of the water returned to the reactor.

Reactor System

In describing the reactor system, reference is made to the figure. Energy produced in the reactor core is absorbed by water flowing through the fuel channels. The resulting steam-water mixture then flows to an external separating drum. Sufficient drum internals are furnished to give the desired purity of the steam flowing to the turbine. Good separation is also required to eliminate the possibility of cavitation in the recirculating pumps.

The water from the separating drum is pumped through the secondary steam generators which extract heat from the fluid. This produces secondary steam and cools the water to give the desired subcooling before returning it to the reactor vessel. There are four separate recirculation loops, as can be seen. Each of these loops consists of a secondary-steam generator, recirculating pump, and secondary valving, and can be isolated as a unit in a separate shielded compartment. After a unit is isolated from the remainder of the system, maintenance in the individual cells can be performed on an 8-hr basis. The plant is capable of stable operation with one or two of the secondary loops completely out of service.

The primary-steam drum is sized to provide approximately 1700 cu ft of water-storage volume. It is approximately $8\frac{1}{2}$ ft in diam and 60 ft long. The drum serves the dual role of reservoir and separating device. The drum size is determined by surges between the reactor vessel and the drum during transient conditions rather than on a steam-water separation basis alone. Steam-water separation is accomplished by using conventional separator devices. The high drum arrangement produces good natural circulation characteristics and increases the available NPSH on the pumps.

The reactor core is a honeycomb structure of square zircaloy-2 channels approx $3\frac{3}{4}$ in. on the side. Each channel which does not contain a control rod has 25 round fuel rods, of approx $\frac{1}{2}$ in. diam, arranged in a square lattice. Control-rod-bearing channels contain 16 fuel rods with 9 rods displaced by the poison-type control rod.

The basic fuel is slightly enriched UO_2 fabricated as a sintered solid and in the form of a cylindrical pellet. A series of these pellets are encased in a zircaloy-2 tubular jacket to form a rod.

The self-regulation control feature of the dual-cycle boiling-water reactor does not eliminate the necessity for a control-rod system to operate when control by steam void formation is not available, i.e., during startup or shutdown, to provide a system of rapid shutdown (scram); to provide a means of controlling the neutron flux distribution in the core; to regulate the ratio of primary steam to secondary steam; and to compensate for long-term reactivity changes in the core due to burn-up and fission-product poisoning. Normally, only one control rod operates at a time, but during scram all 43 can be inserted rapidly.

Enrico Fermi Fast-Breeder Reactor[4]

The Enrico Fermi Nuclear Power Plant near Monroe, Michigan, will convert nuclear energy into electricity through the use of a liquid-metal-cooled, fast-neutron-breeder reactor, and a 156,000-kw 1800-rpm turbine-generator.

The fast-breeder type of reactor was chosen for this plant because such a reactor offers the attractive possibility of utilizing low-cost nuclear fuel in the form of abundantly occurring uranium-238 and thorium. The use of liquid sodium as the reactor coolant permits high-temperature operation without encountering, at the same time, high coolant-system pressures. Utilization of heat of fission at high thermal efficiency, therefore, can be attained.

In general, the core of a fast-breeder reactor will be of relatively small size. The core of the reactor for the Enrico Fermi Nuclear Power Plant is no exception and will consist of a uranium-molybdenum alloy enriched; enrichment is slightly more than 35 times that of naturally occurring uranium. Ultimately, all fast breeders are expected to use plutonium or uranium-233 as fuel, but both of these nuclear fuels are man-made, and neither fuel-element technology nor the supply of these more desirable fuels is sufficient at the present time to permit the building of a large power reactor.

The cost of the Enrico Fermi Nuclear Power Plant is estimated now to be $54 million. Of this amount, $30 million will be spent on the nuclear reactor and its auxiliaries, $14 million will be spent on the steam-electric-generating facility, and $10 million will be spent on research and development and on business expenses during construction.

Organizational Arrangements

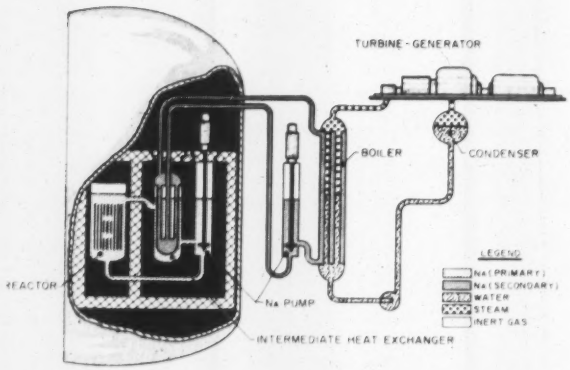
Power Reactor Development Company, a nonprofit membership corporation organized under the laws of the State of Michigan, will finance, design, build, own, and operate the nuclear portion of the Enrico Fermi Nuclear Power Plant.

Atomic Power Development Associates, a nonprofit New York membership corporation will, as a contractor, furnish PRDC with a final design for the reactor proper and for the primary coolant loop.

Simultaneous with the construction of the PRDC reactor plant, The Detroit Edison Company will, at its own expense, construct the electric-generating facilities. A contract providing for the purchase of steam by The Detroit Edison Company has been negotiated recently with PRDC. The contract is predicated on the principle that Detroit Edison at the Fermi Plant should produce power at the bus bar at the same cost that might be incurred in a modern plant which it is currently building.

The assistance of the Atomic Energy Commission has been requested specifically as follows: (*a*) Certain research and development work including the performance of a critical experiment and certain material irradiation tests in its facilities. (*b*) A reasonable amount of consulting service and assistance in the training of operating and maintenance personnel. (*c*) Supply of the special nuclear material required and waiver of use charges for a period of five years. (*d*) All reprocessing services required, to be furnished on a negotiated price basis, except the fabrication from raw materials of core and blanket elements.

[4] Condensed from "Enrico Fermi Atomic Power Plant," by John F. Anderson, Power Reactor Development Company; Weymouth N. McDaniel, Assoc. Mem. ASME, Atomic Power Development Associates, Inc.; and Charles M. Heidel, The Detroit Edison Company; ASME Paper No. 56—A-168.



Heat-utilization system of the Enrico Fermi Nuclear Power Plant. Heat removed from the reactor core and blanket by the primary-system sodium coolant is transferred to secondary sodium coolant in intermediate heat exchangers and finally to water and steam in once-through-type generators. There are actually three primary and three secondary loops arranged radially. The use of the intermediate sodium coolant prevents radioactivation of the water or steam systems, permitting them to be of conventional design.

Reactor Plant Design

The reactor is designed for an initial heat output of 300 mw, with 268 mw being released in the reactor core and 32 mw in the blanket. Ultimately, it is expected that the total heat output will be 430 mw. Initial burn-up of the fuel is set at 1 per cent of the total atoms of fuel alloy. The total sodium-coolant flow rate is 13,200,000 lb per hr, resulting in an average coolant temperature rise across the reactor for 300 mw of 250 F. The sodium-coolant temperatures for this case are 550 F at the inlet and 800 F at the outlet.

Heat is removed from the reactor core and blanket by the primary-system sodium coolant. It is transferred to secondary sodium coolant in intermediate heat exchangers, and finally transferred to water and steam in once-through-type steam generators. There are three primary-coolant loops and three secondary-coolant loops. By using a secondary, or intermediate, sodium system, there is no possibility of producing radioactivity in the water or steam systems, and these systems can be of conventional design.

Core and Blanket Subassemblies. The reactor proper consists of 91 core subassemblies, 546 radial-blanket subassemblies, and 10 control rods, all arranged to approximate a right circular cylinder about 80 in. in diameter and 70 in. in height. The core contains the enriched uranium-235 alloy. It is also approximately a right circular cylinder, 31 in. in diameter and 31 in. high, and is located in the center of the reactor proper.

Sodium coolant flows upward through both core and radial-blanket subassemblies with 90 per cent of the total

coolant flow being directed through the core subassemblies and 7 per cent through the radial-blanket subassemblies. The remaining 3 per cent of the coolant is distributed to the control rods, to the thermal shield, and to an allowance for by-pass leakage.

Design. A core subassembly consists of a $31^{3}/_{16}$-in-long fuel section, positioned between an upper-axial-blanket section and a lower-axial-blanket section. The fuel section contains 144 pin-type fuel elements arranged on a square pitch of 0.1917 in.

The 0.158-in-OD fuel pins are clad with 0.004-in-thick zirconium, metallurgically bonded to uranium-10-weight-per-cent-molybdenum fuel alloy. Stainless-steel wires, disposed at 2-in. intervals along the length of the fuel section, provide spacing between individual fuel pins. The lower end of the fuel pin is anchored, but the upper end is free to expand in length because of temperature changes or irradiation damage. A thin-wall sheath around the bundle of 144 fuel pins is designed to provide for reduced temperature gradients from one side of the subassembly wrapper to the other. Sodium coolant flows in the space between the heavy-wall square wrapper tube and the thin-wall metal sheath. Separation of the two walls is accomplished by the use of spiral-wound stainless-steel wire.

The axial-blanket elements are 0.456-in-diam unalloyed uranium pins, clad in stainless-steel tubes 0.484-in-OD with a 0.010-in-thick wall. The radial clearance of 0.004 in. between the uranium and the tube is filled with sodium to provide a low-resistance thermal bond. The clad pins are held in position in the subassembly by grids located at the bottom and at the top of each axial-blanket section. Allowance for growth in length of the uranium due to thermal cycling and irradiation damage is provided inside the closed cladding tube in the form of low-pressure inert-gas space.

The radial-blanket subassemblies have essentially the same external dimensions and features as the core subassemblies. The radial-blanket elements are 0.145-in-diam unalloyed-uranium pins, placed in 0.010-in-thick-wall stainless-steel tube measuring 0.443-in-OD. As in the case of the axial-blanket element, the radial clearance of 0.004 in. between the uranium and the cladding tube is filled with sodium to provide a good heat-transfer bond.

Control Rods. Space is provided in the central part of the reactor core for 10 control rods, eight safety rods, and two shim rods. All contain the nuclear poison boron carbide. Since naturally occurring boron is insufficient as a poison for fast reactors, the boron carbide in the control rods must be enriched with boron-10 isotope.

The operational, or poised, position of the safety rods is in the upper portion of the axial blanket, where they are held by a mechanical latch. When a scram shutdown is required, the safety (scram) rods are released by the latch and are accelerated into position in the core by both gravity and coiled springs. Deceleration is accomplished by dashpots at the end of the scram-rod travel. The total scram time is less than one second and includes delatching, acceleration through the upper axial blanket, and movement into the core itself.

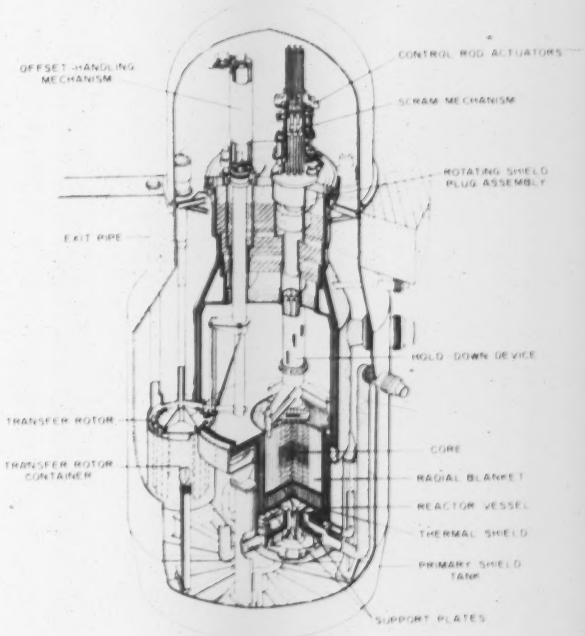
Reactor Vessel. Core and blanket subassemblies, control rods, and thermal-shield subassemblies are contained within a 2-in-thick stainless-steel reactor vessel.

The vessel is penetrated in its upper part by three 30-in-diam sodium-coolant outlet nozzles, three 1-in-diam siphon-break nozzles, and one 2-in. overflow nozzle. Three 14-in-diam core coolant inlet nozzles, three 6-in. radial-blanket coolant inlet nozzles, and one 2-in-diam drain nozzle penetrate the reactor vessel near its lower end. The core and radial-blanket coolant supplies are at different pressures, and enter the corresponding parts of the reactor by separate passages in the reactor-vessel plenum region. By using low-pressure coolant in the radial blanket, no hold-down of these subassemblies is required—their own weight being sufficient to exceed the lifting force of the flowing coolant.

In the core area, because the sodium-coolant velocity is approximately 30 ft per sec, the fluid-lifting force exceeds the weight of a core subassembly by a factor of three or four. A subassembly hold-down plate, operated mechanically from above through the median of a large, stiff, vertical shaft, prevents lifting of any part of the reactor core. This hold-down plate also serves to position accurately the upper ends of the core subassemblies, and to align the control rods at a point just above the reactor proper.

Core, radial-blanket, and thermal-shield subassemblies as well as control-rod thimbles, are supported at their lower extremities by two accurately drilled support and positioning plates, one located 18 in. above the other. These two plates are tied together structurally and are supported ultimately by the reactor-vessel walls.

The two rows of thermal-shield subassemblies provide part of the neutron shielding for the reactor-vessel wall. Additional neutron and thermal shielding is installed in the form of permanent concentric steel cylinders. The quantity of neutron shielding is such that the reactor



The 2-in-thick stainless-steel Enrico Fermi reactor vessel contains the core and blanket subassemblies, control rods, and thermal-shield subassemblies. The vessel is penetrated in its upper part by sodium-coolant outlet nozzles, siphon-break nozzles, and an overflow nozzle. Coolant inlet nozzles for the core and blanket, and a drain nozzle penetrate the reactor vessel near its lower end.

vessel itself never accumulates more than 10^{22} nvt of neutrons above 0.1 Mev. The cylindrical shields are subdivided into thin sheets to prevent the vessel from experiencing adverse thermal shocks due to inadvertent reactor scrams or other temperature transients.

A secondary containment vessel, also called the primary shield tank, surrounds the reactor vessel, the rotating plug and the part of the reactor vessel immediately adjacent to it, and the transfer rotor container. Within the annular space between the reactor vessel and the secondary containment vessel are structural-steel supports for the reactor vessel, the neutron-thermalizing-and-absorbing shield, the gamma shield, and the neutron-flux counters. An important function of the secondary containment vessel is the containment of sodium coolant in the unlikely event that a leak should occur in the reactor vessel.

Type 304 stainless steel is used throughout the primary system to contain sodium coolant. Type 347 stainless steel is used for the subassembly support plates. Practically every accepted test for quality of work will be utilized in order to provide a mechanically strong and leak-tight reactor vessel. Where materials will be subjected to radiation damage, surveillance specimens will be used to keep a continual check on the properties of the structural material.

Borated graphite will be installed in the annulus between the secondary containment vessel and the reactor vessel. Construction of this graphite shield will be such as to minimize the problems of energy release and dimensional growth. Inert gas will be used to cool the graphite.

Fuel Cycle. Probably the most serious economic problem facing the fast-breeder reactor is the necessity for frequent reconstitution of the fuel and the necessity for processing both fuel and blanket materials for bred plutonium. Both reconstitution and plutonium separation, in the case of the Fermi Plant, will be accomplished through use of aqueous chemistry in existing AEC facilities. Some modification of parts of the AEC processing plants may be necessary to get the metallurgically bonded zirconium-clad fuel pins into solution.

The conversion of an aqueous solution of plutonium to metal appears now to be a significant, but not very well defined, factor in the economics of plutonium recovery. The same statement holds true for the aqueous solution-to-metal conversion of enriched uranium.

The fast-breeder reactor for the Fermi power plant contains about one atom of uranium-235 in the fuel alloy for every six total atoms present. With 1 per cent burnup of the total atoms in the fuel alloy permitted before radiation damage necessitates reconstitution of the fuel, about 5 per cent of the uranium-235 will have been destroyed. Thus, a fissionable uranium-235 atom may have to be reprocessed on the order of 20 times before it is finally consumed. There are large charges associated with this much reprocessing, particularly with respect to inventory chemical losses, and the conversion-to-metal step.

Turbine-Generator Plant Design

The Power Reactor Development Company will initially supply Detroit Edison with 1,015,000 lb per hr of steam at 600 psia and 755 F. The Detroit Edison Company has contracted to return feedwater at 400 F. After a two-year period, PRDC will provide 1,470,000 lb per hr of steam at 900 psia and 820 F. The Detroit Edison Company must return feedwater for this flow condition at 430 F. The turbine and all auxiliaries will be designed for the latter conditions.

P. A. R. Homogeneous Reactor[5]

THE Pennsylvania Advanced Reactor Project is a major development effort jointly sponsored by Westinghouse Electric Corporation and the Pennsylvania Power and Light Company. Its function is to carry out the experimental and analytical studies leading to the design of an aqueous homogeneous reactor plant having an electrical output of 150,000 kw. This plant is to operate on the PP&L system in eastern Pennsylvania and is planned to be in operation by 1962.

Aqueous Homogeneous-Reactor Types

The words "aqueous homogeneous-reactor concept" encompass a great variety of systems which have been proposed to date, many of which have been actively studied,[6,7,8] and a brief review is worth while. In many reactor types, the fuel, moderator, and coolant are physically separate and distinct. In the aqueous homogeneous reactor they are all intimately mixed. The moderator, either H_2O or D_2O, carries the fissionable material in either solution or suspension, and the whole circulates through a piping complex consisting of a reactor vessel, a heat exchanger, and a pump.

The reactor vessel is of such size that the quantity of fuel contained is equivalent to a critical mass and thus can sustain the fission process. The heated liquid is pumped to the heat exchanger where it gives up its heat to form steam in the secondary system and then is returned to the vessel to repeat the cycle. In contrast to the fixed-fuel type of reactor, the homogeneous system offers a number of important advantages. The problem of transferring heat at very high fluxes from fuel through cladding to coolant is obviated. Because of the absence of structural material within the core, more efficient use can be made of the neutrons born in fission. As the fuel is consumed, the fission products can be removed and fresh fuel added continuously, in contrast to the down time required by solid-fuel reactors. Because fuel as well as moderator decreases in density with an increase in temperature, the homogeneous reactor can be inherently more stable with respect to power surges.

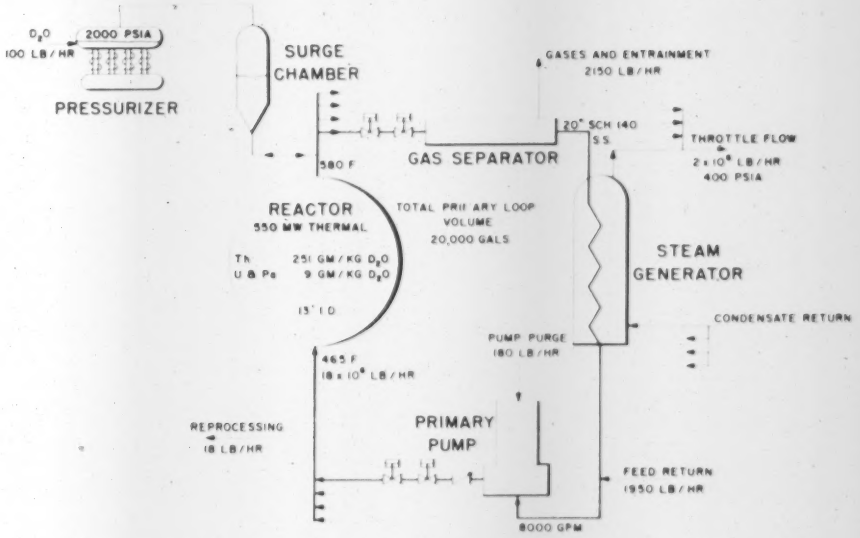
"Simple Burner." The first of four types of homogeneous systems under consideration is a "simple burner" in which the fuel is highly enriched uranium-235 as a solu-

[5] Condensed from "The P. A. R. Homogeneous Reactor Project," by W. E. Johnson and D. H. Fax, Westinghouse Electric Corporation, Commercial Atomic Power Activities, Pittsburgh, Pa., and S. C. Townsend, Atomic Power Department, Pennsylvania Power and Light Company, Allentown, Pa.; ASME Paper No. 56—A-170.

[6] "Aqueous Homogeneous Reactors for Central Station Power," by R. B. Briggs, presented at the Annual Meeting, Chicago, Ill., Nov. 13–18, 1955, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

[7] "Aqueous Homogeneous Power Reactors," by R. B. Briggs and J. A. Swartout, Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, August, 1955, United Nations, New York, N. Y., paper P/496 USA, vol. 3, pp. 175–187.

[8] "The Homogeneous Reactor Test," by S. E. Beall and J. A. Swartout, Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, August, 1955, United Nations, New York, N. Y., paper P/498 USA, vol. 3, pp. 263–282.



Primary loop design parameters for Reference Design One of the P. A. R. Homogeneous Reactor project. The system circulates a mixed oxide slurry of a concentration of about 260 gm per kg of D_2O, corresponding to a solids concentration of about 3 per cent by volume. In the reactor vessel the fission process releases 550,000 kw of thermal power, which in turn yields 150 electrical megawatts through an over-all thermal efficiency of about 27.5 per cent.

tion of uranyl sulphate. Since no fertile material such as uranium-238 is present, no conversion or production of additional fissionable material can occur, hence the name "simple burner." The plant costs for this process would probably be the lowest of the four considered, but since highly enriched fuel is burned, the resulting total energy costs would be prohibitive in most cases.

"*Heavy Solution.*" The high fuel cost encountered in the first type could be reduced if it were possible to use slightly enriched uranium as the fuel. In this case the fission neutrons captured by the U-238 could be used to produce plutonium, which in turn could be used as fuel or sold as a by-product. To make this system economically feasible, very high concentrations of uranyl sulphate are required, hence the name "heavy-solution" type. The heavy solutions used to date are extremely corrosive and have severe limitations with respect to thermal stability. While under active study at Oak Ridge National Laboratory and elsewhere, they do not appear technically feasible for construction in the immediate future.

"*Single-Region" Slurry Reactor.* The third type would be similar to the second but operate on the thorium-uranium cycle rather than on the better-known uranium-plutonium cycle. Thorium-232, upon capture of a neutron converts to U-233 which is fissionable and could in turn be used as fuel or sold as a by-product. Unfortunately, the only soluble thorium compounds are not stable at reactor temperature and radiation conditions, and cannot be used as reactor fuels.

Thorium oxide, on the other hand, is quite stable. The principal difficulty is that the primary system and most of the auxiliaries must be designed to pump and handle a quasi-homogeneous suspension or slurry. There are at least two ways of building a slurry reactor. In the first of these, the thorium and uranium are intimately mixed and, to distinguish it from its counterpart, is called the "single-region" slurry reactor.

"*Two-Region" Slurry Reactor.* The fourth and last type is the "two-region" reactor. The reactor proper consists of a central-core region, or seed, of highly enriched uranyl sulphate surrounded by a circulating blanket of thorium oxide slurry, and separated from it by a core liner. The major fraction of the fission heat is released in the core region, and neutrons, passing through the core liner, bring about conversion in the blanket.

The P.A.R. Project is concerned primarily with these latter two types, the single-region slurry reactor and the two-region reactor. Both have excellent possibilities of being breeder reactors and thereby attaining what so many people thought was the main attraction of nuclear power—zero or nearly zero fuel cost. If the capital and operating costs can be kept low enough, competitive power is at hand.

P.A.R. Project Objectives and Organization

The primary objective of the P.A.R. Project today is to investigate and compare these two types of plants as to technical feasibility problems yet to be solved and economics, and to select one for detailed design and construction as Phase 2 of the program.

The work falls naturally into three major categories: The determination of the physical and chemical properties of thorium and uranium slurries; the development of plant components; plant design and layout.

Chemical reprocessing of spent fuel is an important aspect of any reactor. The Union Carbide Nuclear Company was interested in studying various possibilities, and early in the life of the P.A.R. Project became a third partner to the agreement.

A total of 61 PP&L, UCNC, and Westinghouse engineers and scientists, and 18 technicians are working full time on the project, not including the Stone & Webster group, other Westinghouse Divisions, or other vendors.

Reference Design One

By the time the Project was six months old, it became quite apparent that we could not afford the luxury of studying reactor physics, systems engineering, component design and plant layout, and maintenance as

separate and discrete problems for two years and hope to put together, at the very end of Phase 1, the best plant with which to enter Phase 2 of the project. A series of Reference Designs was instituted to co-ordinate the studies of our several groups insuring that at the end of Phase 1 a body of self-consistent information will be available.

The first of these is a single-region slurry reactor which circulates a mixed oxide slurry of a concentration of about 260 gm per kg of D_2O, corresponding to a solids concentration of about 3 per cent by volume. In the reactor vessel, the fission process releases 550,000 kw of thermal power, which in turn yields 150 electrical megawatts through an over-all thermal efficiency of about 27.5 per cent. The pressure vessel has a 15-ft OD and a wall thickness of 6 in. Just inside the wall are a number of thermal shields which absorb the major fraction of the gamma radiation issuing from the core. These are cooled by a portion of the main slurry stream which also reduces the thermal stresses in the pressure-vessel wall.

The electrically heated pressurizer maintains a system pressure of 2000 psia, which is well above the vapor pressure of the fluid in the primary loop. The pressurizer contains only D_2O and is separated from the surge chamber by a steam space, avoiding the caking which would probably result were the slurry itself to be boiled.

Leaving the reactor vessel, the slurry branches into four parallel identical loops. Each of the loops can be isolated from the reactor by two pairs of dual stop valves to permit certain types of remote maintenance to be performed without shutting down the entire plant. In the reactor vessel, part of the kinetic energy of the fission fragments is absorbed by water molecules which are dissociated into deuterium and oxygen in the process. The major part of these radiolytic gases is recombined internally through the action of a suitable catalytic agent. About 10 per cent is left unrecombined in order to help sweep out the gaseous fission products, principally xenon, which would otherwise lessen the efficiency of the neutron utilization. These gases are removed from the main stream in the gas separator, which consists of a set of vanes to produce a centrifugal field and a second set designed to recover the major part of this rotational kinetic energy. The slurry gives up its heat in the steam generators and is returned to the reactor vessel by the hermetically sealed canned-motor pumps, one in each of the four parallel loops.

Several fluid streams enter and leave the primary system. The largest single stream is the mixture of gases and vapor leaving the gas separators. A small stream of D_2O is introduced at the motor end of each primary pump to maintain the bearings free of slurry. A second small stream of water goes to the steam pressurizer to compensate for condensation at the slightly colder interface in the surge chamber. A very small stream is bled from the primary loop to the chemical processing plant where the nongaseous fission products are removed and make-up fuel added. The reconstituted slurry, together with the balance of the recombined deuterium and oxygen which had been removed in the gas separator, re-enter the system near the suction of the primary pumps.

The xenon and krypton born in the fission process are held up on charcoal beds in the off-gas system until their radioactivity has decayed sufficiently so that, when diluted, they may be vented to the atmosphere. The off-gas system performs the same function for gases generated in the chemical processing plant.

Development Program

Without doubt, the most formidable problem that arises in connection with the homogeneous reactor plant is that of maintenance. Not only is the radioactivity of the fuel transported throughout most of the reactor plant intense, but those components in the primary system, which are exposed to the delayed neutron emission, become radioactive in depth, and no amount of flushing or cleaning will make them accessible for direct repair by conventional methods.

A second set of problems peculiar to the slurry plant is that associated with the pumping and handling of the slurry itself. The slurry particles are hard and quite abrasive. In stagnant regions the slurry tends to settle rapidly and may, under adverse circumstances, form a hard cake. At the outset of the development program, these and similar problems loomed largest on the horizon. Nevertheless, positive results have been obtained in a twofold attack. In the physical chemistry laboratories, measurements are made of particle sizes, settling rates, particle surface charges, redispersibility, and other rheological properties as affected by temperature, chemical additives, method of preparation, and mechanical treatment. In the engineering laboratories, tests are made of the findings of the physical chemistry laboratories in equipment more nearly approximating that of a real plant.

We have accumulated more than 3000 hr of pumping slurry at reactor temperatures. The longest continuous runs have been of 1000-hr duration and these have been terminated only for the removal of corrosion specimens. Shutdowns on a number of occasions allowed the slurry to settle under both hot and cold conditions, and the pump was restarted without trouble. In so far as corrosion and erosion are concerned, tests confirmed ORNL results that attack on stainless steels will not exceed 2 mils per yr at velocities under 30 ft per sec, provided a suitable chemical environment is maintained. Extension of these investigations will include other materials and experimental conditions.

The effects of high-intensity radiation on the slurry particles and on the behavior of the recombination catalyst are yet to be determined for circulating systems.

The third part of the program has to do with the design of plant components. These must withstand high levels of radiation, be essentially leak-tight, yet easy to maintain by remote or semiremote means. In some cases they are close to the upper limit of present-day technology in regard to size. An adequate initial attack consists in the study of modifications of existing designs.

A second category of components is that in which almost no prior experience is available upon which to draw. One example of this is the high-head-slurry make-up pump; a second is the slurry-let-down device. Several promising ideas are being tested for both.

Even if these ideas or others to follow prove sound, the step from the successful operation of small loops to the design of a large plant is not easily made, and an intermediate scale loop has been designed to bridge this gap.

Summary

The accumulation of more than 3000 hr experience with successful pumping of thorium oxide slurries in concentrations and temperatures appropriate to the single-region reactor leads to the conclusion that technical problems associated with the plant will be settled within the time scale set. The conclusions in regard to the economics of the plant are more cautious. While in the case of a breeder plant the bare fuel cost is essentially nil, the fixed charges are quite another matter. The cost analysis for the first Reference Design is just being completed, but it is certain to be quite high. On the other hand, if the present efforts in the direction of system simplification and the development of maintenance techniques are successful, a competitive power plant is in sight.

Sodium-Graphite Reactor*

THE Sodium-Graphite Reactor (SGR) is a low-pressure, high-temperature, liquid-metal-cooled system using solid fuel and solid moderator proposed for the Consumers Public Power District of Nebraska. The SGR has both immediate technical feasibility and potential for future improvement. Among its more important features are:

1 A high coolant temperature—925 F at present—is possible without requiring pressurization of the reactor heat-extraction system. This permits good steam conditions and high thermal efficiency in the power-conversion equipment.

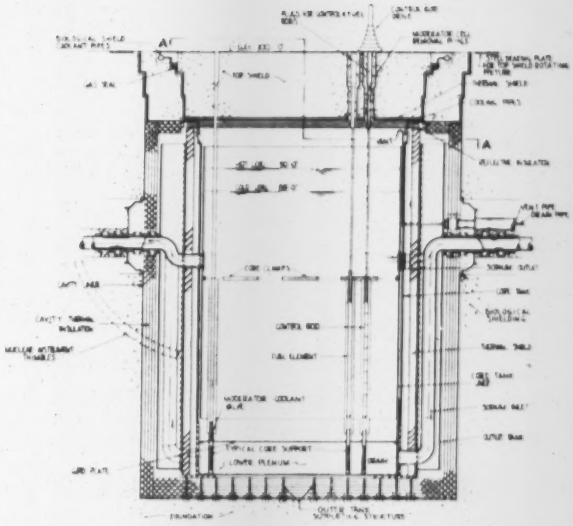
2 The reactor can be adapted to a variety of fuel elements and operating conditions. Both slightly enriched uranium or a thorium-uranium fuel may be used.

3 There are no chemical incompatibilities in the fuel-element, coolant, structure combination.

4 The absence of releasable potential energy from pressurization or chemical reactions increases the inherent safety of this reactor system and permits the plant configuration to be easily arranged to contain radioactivity under all circumstances.

The use of a liquid metal such as sodium as a heat-transfer fluid has many advantages. While solid at room temperature, it melts at 208 F and is therefore easy to keep liquid in a power-plant system. Sodium boils at 1620 F and thus permits adequately high coolant temperatures with the system at atmospheric pressure. Because liquid metals, sodium in particular, have extremely high thermal conductivity, they are excellent heat-transfer media. The fluid dynamics of liquid sodium is similar to that of water. A further advantage of sodium is the general absence of chemical corrosion in metal systems. Because of these characteristics of sodium, the engineering development of the Sodium Graphite Reactor and its heat extraction system may eventually permit the production of steam temperatures which will be limited only by turbine performance.

Sodium is not without certain disadvantages. It reacts chemically with oxygen and water and must be isolated from these. Further, when exposed to neutrons as in a reactor, it becomes a strongly radioactive gamma-ray emitter with a half-life of about 15 hours, and this creates a serious problem in nuclear-power-plant applications. For these reasons, in the present concept, the steam boiler has been separated from the primary sodium, which extracts the reactor heat, by a secondary sodium system, which does not become radioactive, and carries the heat from the primary system to the steam generator. The shielded cells necessary to contain the radioactive primary sodium provide the shielding required, and also act as a container for the inert-gas atmosphere which surrounds the primary system.



The Sodium-Graphite Reactor is a low-pressure high-temperature liquid-metal-cooled system using solid fuel and solid moderator. High coolant temperature permits good steam conditions and high thermal efficiency in the power-conversion equipment. The active reactor core, consisting of fuel and moderator elements, is a cylinder approx 12 ft in diam by 10 ft high, enclosed in a 2-ft-thick graphite reflector.

The choice of graphite as a moderator results from the fact that graphite is mechanically easy to handle, as compared to any liquid hydrogenous moderator, and is less costly than beryllium, which might also be used. The principal disadvantage of graphite is associated with its porosity, which causes it to act as a sponge when in contact with liquid sodium. For this reason the graphite is contained in zirconium metal cans in the present design of this type of plant.

In 1954, North American Aviation, Inc., entered into a joint program with the U. S. Atomic Energy Commission to build an experimental sodium-graphite reactor and thus extend the known area of information on the sodium-cooled, graphite-moderated reactor concept. This 20,000-thermal-kilowatt pilot reactor, known as the Sodium Reactor Experiment (SRE) is being installed as a separate facility at the company's field laboratory in the Santa Susana Mountains, near Canoga Park, Calif.

It was originally planned merely to dissipate the reactor heat through air-blast heat exchangers. However, the Southern California Edison Company has recently been authorized to use this heat to produce electrical power. A complete steam-generating plant has been installed with a capacity of 7.5 electrical mega-

* By F. C. Gronemeyer, R. C. Gerber, H. M. Hagaman, H. B. Holz, H. A. Ross-Clunis, and E. F. Weisner, all of Atomics International Division, North American Aviation, Inc., Canoga Park, Calif. Condensed from ASME Paper No. 56—A-171.

watts, which Southern California Edison Company will feed into its regular transmission lines and sell commercially.

The ultimate aim of the Sodium Reactor Experiment is to provide the technological data and operational experience required to attain improved reactor performance, plant investment economies, and simpler maintenance procedures.

The plant described in this paper follows the general specification of the 75,000 net electrical kilowatt power plant which has been proposed by Atomics International to the Consumers Public Power District of Nebraska. However, only the steam-generating facility and the sodium-reactor heat source will be described herein.

Table 1 Design Objectives—Sodium-Graphite Reactor

Steam Production at Turbine Throttle	
Rate	710,000 lb/hr
Pressure	800 psig
Temperature	825 F
Reactor Operating Data	
Nominal rated output	245 Mw (thermal)
Average specific power in fuel	473 kw per kg U-235
Average power density in fuel	3.36 kw per cu in.
Average thermal flux in fuel	2.0×10^{13} neutrons per sec per sq cm
Peak thermal flux in fuel	4.3×10^{13} neutrons per sec per sq cm
Initial atomic per cent of U-235 in fuel	2.3
Uranium inventory	22,500 kg
Probable conversion ratio	0.71
Reactivity	Xenon poisoning 3.0 per cent Temp. effects 0.5 per cent Fuel depletion 2.0 per cent Xenon transient 1.0 per cent (full load to 20 per cent of full load)
Fuel-element temperature	1200 F max
Sodium inlet temperature	500 F
Sodium bulk outlet temperature	925 F
Sodium flow rate	6.4×10^6 lb per hr
Average burnup	3000 Mw days per ton
Load Factor	
Operating time	90 per cent
Shutdown time, refueling	6.5 per cent
Shutdown time, maintenance	3.5 per cent
Electrical-plant load factor (assumed)	90 per cent
Plant net load factor	81 per cent
Radiation Tolerance	
Exposure level, roentgen per wk	0.3

Basis for Design

The reactor and process systems are essentially extrapolations of the design for the Sodium Reactor Experiment. There are features which are not subject to extrapolation and these must be engineered and designed without benefit of previous experience. As results of the testing program and operational data become available from the Sodium Reactor Experiment, they shall be evaluated and will be reflected in the final design.

Specifications for materials, fabrication, welding, installation, and quality control are rigid and based on the experience gained in fabricating and constructing the Sodium Reactor Experiment. The importance of carefully selecting materials and equipment, and the quality of workmanship in the fabrication and installation of equipment and piping, cannot be overemphasized.

Reactor Core

The active reactor core, consisting of fuel and moderator elements, is a cylinder approx 12 ft diam by 10 ft high, enclosed in a 2-ft-thick graphite reflector. The entire core assembly is contained in a stainless-steel core tank.

Moderator and Reflector Elements. The moderator elements are graphite columns contained within sealed hexagonal zirconium cans having 0.035-in. wall thickness. Each moderator element has a central fuel channel and coolant tube.

Fuel Elements. A fuel element consists of a cluster of fuel rods suspended from the top shield in a coolant channel among the moderator elements by means of a hanger rod and plug. Each fuel rod consists of thin-wall stainless-steel tubing containing slightly enriched uranium fuel slugs. After the fuel slugs are inserted into the stainless-steel tubes, the voids are filled with sodium-potassium alloy which provides a thermal bond between the fuel slugs and the tube wall. A helium-filled expansion volume is provided at the top of each fuel rod. The fuel rods are assembled into a 19-rod fuel cluster.

Control and Safety Elements. The control-rod elements are self-contained, operate in a thin-walled steel thimble which extends from the top of the top shield down through the core, and are made up of a series of boron-nickel-alloy rings suspended on a steel pull tube. Control-rod motion is obtained by driving a shaft attached to the pull tube. The motorized drive mechanism, which actuates the drive shaft, is located above the top shield.

The safety rods operate within thimbles similar to the control rods. The poison column consists of a series of boron-nickel alloy rings mounted on an internal tube and actuated by a motorized drive located above the top shield. A latch mechanism is utilized to release the safety rods at any time regardless of position. The safety rods fall into the reactor core by gravity.

Reactor Structure. The main components of the reactor structure are the top shield, core-supporting structure, core tank, thermal shield, outer tank, outer-tank-supporting structure, cavity insulation, and cavity liner.

Top Shield. The top shield is cylindrical, about 22 ft in diam and $7\frac{1}{2}$ ft thick. The shielding concrete is a high-density concrete of magnetite-iron-ore aggregate and steel-shot grout. The shield is penetrated by vertical holes aligned with the fuel channels. These holes are normally filled by shield plugs which support the fuel elements and the control and safety rod thimbles. The complete top shield will weigh about 270 tons. Thermal-radiation insulation is provided on the underside of the top shield, and consists of a bottom shield plate and a low-carbon-steel plate separated by a layer of lead. Tubing for circulation of organic coolant is embedded in the lead layer. A gas seal between the cavity liner and top shield is made by casting a low-melting-point alloy in a suitably shaped trough.

Core Supporting Structure. The core is supported by hollow pedestals attached to the bottom of the moderator and reflector elements. The pedestals extend through a grid plate and rest on the bottom surface of the core tank. The grid plate acts as a diaphragm separating the lower plenum from the region around and between the moderator and reflector elements. The main sodium flow enters the hollow pedestals from the lower plenum and

flows up the central tube in the moderator elements around the fuel rods. A small percentage of the sodium flow is orificed through the grid plate to cool the moderator cans.

Core Tank. The core tank is fabricated of stainless-steel plate, and is approximately 28 ft high and 17 ft in OD. The design temperature for the tank is 1200 F; the design pressure for the region below the grid plate is 44 psig and for the region above the grid plate, 19 psig. The tank is also designed to withstand thermal stresses which may occur due to the 425 F temperature difference between the bottom and top of the tank. The thermal neutron shield consists of a stack of cast-steel rings with an ID of about 18 ft and a thickness of about $7^1/_2$ in.

Outer Tank. The outer tank consists of a cylindrical shell with a flat bottom about $28^1/_2$ ft high and 20 ft in diam. The cylindrical configuration of the shell of the tank is modified by two channel-shaped extensions diametrically opposite from each other to accommodate the sodium piping.

The core tank and the outer tank are both subject to rigid tests to insure leak-tight construction.

The outer-tank-supporting structure consists of a number of concentric cylinders resting upon circular bearing plates. The cylinders are carefully machined to the same height to insure proper bearing at all points.

The cavity thermal insulation consists of diatomaceous silica and asbestos blocks.

The cavity liner consists of a cylindrical tank about 20 ft in diam and 40 ft high. The cavity liner serves as the outermost barrier for the reactor, as the bearing surface for the outer-tank-supporting structure, as the attachment point for the various reactor cells and expansion bellows, and, during construction, as the inner form for the concrete biological shield. Biological shield-coolant pipes, fed by a manifold located around the top of the liner, are fastened to the outside of the cavity liner to maintain the concrete at a permissible temperature.

Sodium Heat-Transfer System

More than 98 per cent of the total energy produced in the reactor is removed from the core by the sodium coolant. The sodium heat-transfer system consists of three separate circuits, each capable of removing one third of the available heat in the reactor. Each circuit is divided into two loops. The primary loop circulates radioactive sodium through the reactor and the intermediate heat exchanger (tube side) where the heat is transferred to nonradioactive sodium in the secondary loop. This nonradioactive sodium is then used to generate steam. To prevent any contamination of the secondary sodium the secondary loop pressure is kept above that of the primary loop. Expansion tanks are provided in the secondary loops to release entrained helium, to allow free expansion as the sodium is heated and to pressurize the system. The reactor-core tank serves as an expansion tank for the primary loops.

Heat Exchangers. The intermediate heat exchangers are of standard shell-and-tube design with all-welded construction.

The steam generators are connected by a common steam header and are of the kettle type with superheater. The use of the "once-through" type of steam generator is being studied and the results of these studies will determine the type specified for the final design.

During power operation, at least two heat-transfer circuits must be in operation so that one can remove afterglow heat in case the other fails. In the event of a power failure the sodium pumps will operate on emergency power at reduced speed. The steam generator is also supplied with an emergency feedwater system.

Sodium Fill, Drain, and Flush System

The sodium fill, drain, and flush system consists of a sodium receiving and processing station, primary fill tanks for the radioactive primary system, secondary fill tanks for the secondary system, electromagnetic pumps for transferring sodium and associated piping.

Sodium Purification System

The sodium purification system is provided to perform the following functions:

1 Remove oxygen from the sodium in the primary fill tanks before the sodium is introduced into the reactor

2 Measure the amount of oxygen and remove oxygen from the sodium heat-transfer systems during operation. (It appears desirable to reduce the oxygen content of the primary sodium to less than 10 parts per million.)

3 Dispose of the collected oxygen.

Cold traps and plugging meters are utilized to accomplish the above functions.

Cold traps are used to remove oxygen from the system. These units utilize the temperature dependence of the solubility of sodium oxide in sodium. If the sodium is cooled below the sodium-oxide-saturation temperature the oxides will precipitate out and can be collected.

In each circuit a plugging meter is provided to determine the oxide content. A plugging meter consists of an orifice, a cooler for sodium, and temperature and flow-recording devices.

Other Special Systems

The organic cooling system provides cooling for all components in the reactor plant that are to be maintained at controlled temperatures. Since the organic cooling system provides services in areas where possible leakage might result in a reaction with sodium, a coolant relatively inert to sodium is used. Tetralin possesses desirable characteristics for such a coolant, and its use is contemplated.

A helium system is used to establish an inert-gas atmosphere where necessary within all piping, vessels, and equipment containing sodium. A nitrogen system is used to establish an atmosphere (less than five per cent oxygen) in the following areas: hot-pipe tunnel, heat-exchanger cells, primary fill-tank cell, disposable colds trap cell. The radioactive vent system collects all gases that are, or could be, radioactive and stores them until their activity has decayed sufficiently to allow them to be released to the atmosphere. The gases consist mostly of helium, nitrogen, air, hydrogen, and water vapor. Radioactive gases from various sources are collected in a compressor suction tank. Radiation indicators operate solenoid valves to vent the gases either to the atmosphere if below tolerance levels or to the compressors if too radioactive to be released directly. Two compressors pump the contaminated gas to decay tanks where they are stored until they can be released through the ventilation exhaust stack.

Standardization Problems of a Reactor Designer

The need for standards in developing a design for a reactor or its major components

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WHEN a new field is entered, the lack of adequate and acceptable standards and specifications suitable to meet new requirements is immediately evident. The use of nuclear energy as a heat source for steam power production constitutes a completely new field in power generation and presents many unique problems for which standards, specifications, and codes are not available.

In the developmental period where changes occur rapidly, the question always arises as to the proper time for preparation of a specification, code, or standard. If these documents are prepared too soon, they are likely to be more harmful than helpful, since standardization of an item or component which is being revised frequently as a result of development could well be a handicap. On the other hand, an unreasonable delay can result in preparation of many individual specifications or standards for the same product. A reconciliation of these, once established, may create more of a problem than preparation of an entirely new standard. In the meantime, an intolerable situation may develop for the manufacturer, as well as the user, as a result of multiplicity of divergent standards, codes, and specifications. There is an optimum time for the preparation of standards, although the determination of that time is often very difficult. In certain areas pertaining to power generation by nuclear means, that time appears to be here.

Some significant differences which are related to nuclear rather than conventional power generation follow.

Radiation Effects

Effect on Stability of Materials. Important gains in steam-turbine cycle efficiency have resulted primarily from development of new materials able to withstand satisfactorily the ever-increasing steam temperatures. Materials play an important part in nuclear power generation, but other characteristics in addition to high-temperature strength and stability are required. Materials subjected to neutron bombardment as a result of nuclear fission may suffer a serious change in tensile strength and ductility. In the fuel materials, serious changes in density and volume may occur. Present material specifications are, of course, not concerned with this. When adequate test information becomes available, and experience has been accumulated over a period of years, it may be possible to describe or specify what is desired in terms of the ability of a material to retain its engineering properties under sustained neutron bombardment of specified intensities and life. This will apply to structural materials, fuels, control rods, conductors, semiconductors, and other reactor parts or components.

Need for Leak Tightness and Perfection. Because of the need for absolute integrity and leak tightness of systems and components, new methods of test may be utilized, or tests now used may be amplified. For instance, mass spectrometer leak tests are now being specified to determine leak tightness of complete vessels as well as welded joints. No accepted standard specifications for leak testing by mass spectrographic methods now exist. On the other hand, ultrasonic testing of such items as turbine and generator shafts, and pipe is being used for conventional power plants and even more extensive use of this tool will be made in construction for nuclear reactors. A materials failure is undesirable in any equipment. In the case of nuclear equipment subject to irradiation, the material itself may become radioactive, making repair work difficult, if not impossible, and it becomes most important that the job be as nearly perfect as possible the first time.

Special Properties of Materials

Neutron Absorption. Another property of materials most important in the design of nuclear reactors is the tendency to absorb neutrons, a characteristic defined as its "capture cross section.". A material entirely satisfactory in all other respects may be discarded because of its great affinity for neutrons. Small quantities of extraneous elements may be of considerable significance.

There are new metals used for reactors which have heretofore received scant attention. Zirconium, which was a laboratory curiosity only a few years ago, is now one of the new metals being made in considerable quantities for nuclear components. Graphite and beryllium have attained added significance as a result of special nuclear properties.

While the foregoing discussion has concerned metals, another structural material of great importance in nuclear power plants is concrete. Again, to be most effective, certain special requirements should be added to existing concrete specifications. Density, homogeneity, type of aggregate, and method of placement are all of greater importance than for the usual structural use. Further, certain special types of concrete utilizing neutron-absorbing additives, such as barites, pyrites, and ferrophosphorus are commonly used.

Dimensional Standards

Since it may be necessary to assemble or disassemble joints remotely because of radioactivity of the compo-

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New problems arise in the utilization of nuclear energy which are peculiar to it and create the need for new standards and specifications, or the revision of existing codes. For example:

1 **Radiation not only affects the stability of materials, but requires remote-handling techniques, new methods of inspection, and special surface finishes in some cases. New health hazards are introduced, and leak-tightness becomes vital.**

2 **The unusual characteristics of fissionable materials will eventually require new standards for the fabrication and processing of fuel-element assemblies.**

3 **Materials specifications should provide for use of special fluids such as lead-bismuth, uranyl sulphate, uranyl phosphate, and others. Corrosion problems should be considered more specifically than heretofore.**

4 **The special properties of certain materials now in use, such as their affinity for neutrons, and the new metals which are being brought into prominence for particular properties, all introduce new problems.**

5 **New media used for heat transfer require a broader understanding of satisfactory handling techniques and provision of suitable materials to contain them.**

nent parts, new standards for thread fits may be required. The need to eliminate galling of bolts and nuts, and remote maintenance of valves and equipment may also require special consideration.

Likewise, the standard for flanges and flanged fittings may require revision to adapt it to remote assembly and disassembly of flanged joints. It may be desirable to secure tightness with lower gasket pressures and bolt loadings. Further investigation is needed to determine what gasket materials will be satisfactory and how leak-tightness can be achieved with existing or new designs of flanges and flange facings.

Greater consideration must be given to the possibilities of radioactive contamination of the interior of pipe, valves, and fittings as a result of deposition of radioactive particles. This may require specifications of standards of surface finish for the inside of pipe. Likewise, greater attention should be given to the interior condition of valves and fittings to minimize crevices or any other discontinuities in which gamma-emitting particles may reside.

Safety Codes

As in any industrial operation, ultimate responsibility for safety both in design and operation must rest with the owner and operator of the facility. Since little experience has been had in the operation of nuclear reactors, or with the extent of the damage which could occur as the result of an accident, final approval as to the safety and safe operation of nuclear reactors now resides in the United States Atomic Energy Commission. Ultimately, it would appear that safety codes will be developed, perhaps through the American Standards Association, which will cover all aspects of the design and operation of nuclear reactors. Administration of such codes could be through state agencies, as is the case with the very successful application of The American Society of Mechanical Engineers Boiler Construction Code.

Until such a code or codes are developed, full use should be made of existing codes, where applicable. An example concerns the design and fabrication of two important parts of the reactor complex—the reactor vessel and the outer containment vessel. Conventional rules used in design of pressure vessels are not directly applicable to nuclear vessels in many cases, either because of the size or because of nonconventional operating conditions. In some types of reactors thermal shock as a result of rapid load change may be an important consideration. Reactor designers have felt that some deviation from present stress allowances for materials, as designated in ASME codes, should be permitted for transitory high stresses of short duration. Present stress allowances are based on steady-state conditions and, if adhered to in design of reactor vessels, would result in unsatisfactory designs, both economically as well as from a performance standpoint. A special task group of the ASME Special Committee on Nuclear Power has this matter under consideration.

More importance is attached to stress concentrations resulting from such points as notches, discontinuities, and short-radius fillets, again, because of the embrittling effect of nuclear radiation.

Another case where an existing code is being made to apply concerns the construction of the outer containment vessel for nuclear reactors, some of which, at least, will be designed in accordance with the requirements of the ASME Code for Unfired Pressure Vessels. Such vessels may vary from 75 to 150 ft in diam or more with a height of 100 to 150 ft. The vessel, in the case of the Power Reactor Development Company reactor, is intended to operate at substantially atmospheric pressure, but the design will be based on containment of a pressure resulting from some hypothetical failure which might raise the internal pressure to as much as 40 lb per sq in. The Unfired Pressure Vessel rules clearly were never intended to cover this concept, but it appears that their requirements can be revised satisfactorily to provide at least an adequate set of design rules for an interim period.

New Inspection Methods Must Be Devised. Another special requirement for nuclear systems concerns reinspection of vessels after operation. Once installed, annual inspection will be very difficult because the vessel will be radioactive. New means or methods of inspection must be devised. At present, it is proposed in some cases to include surveillance specimens which can be removed from the vessel and examined at specified intervals during the vessel life.

There are many existing American Standard safety codes which provide rules for construction of systems or structures having similar components, yet they are not entirely applicable. For instance, the American Standard Code for Pressure Piping has had wide acceptance and use in the construction of piping systems for power, district heating, gas and air, and other purposes. Yet, for liquid-metal-cooled reactors, for instance, there

are no provisions for design and construction of piping systems for handling liquid metals. Neither are there any requirements which may be needed to provide for special operating conditions associated with the boiling-water reactor. Requirements might be included to provide for other fluids not now covered, such as lead-bismuth, uranyl sulphate, uranyl phosphate, and others. In some of these cases, it probably will be necessary to consider corrosion more specifically than heretofore, as well as the possible effect of radiation on corrosion rates. A review is now being made by Sectional Committee B31 to determine what modifications are needed to provide for piping associated with nuclear installations.

No attempt will be made herein to cover completely application of existing codes to nuclear construction. However, mention of a few more examples may illustrate the magnitude of the problem. The American Standard Safety Code for Building Construction and the Building Exits Code will not satisfactorily provide for a nuclear installation, since it is necessary to devise standards for testing buildings for leak tightness. This also involves the provision of exits which can be made leak-tight. Further, the American Standard Safety Code for Floor and Wall Openings is involved because of the necessity to provide for leak tightness of incoming and outgoing pipelines of various kinds.

The American Standard Code for Plumbing Systems and the National Plumbing Code should be revised to include systems for collecting and storing radioactive wastes. Leaks, vents, number and location of drains, sumps, pipe joints, and so on, must be reviewed. This includes collection of wastes, possibly contaminated, from reactor buildings, buildings for fuel-element manufacture, laboratories, laundries, and other locations where contaminated materials are handled. Such systems must be designed in accordance with the codes and yet have the necessary provisions for handling radioactive solutions and for preventing the spread of radioactive materials in the case of any type of accident.

New Standards

While the foregoing examples indicate some areas where revisions of existing codes and standards are needed, many new standards will eventually be required to satisfy the needs of the nuclear field. For instance, there is need for an inspection procedure for cleanliness during construction of nuclear equipment that goes far beyond present practice. This applies particularly to the primary and, where used, the secondary heat-transfer circuits of power reactors. The inspection procedure should cover dust, inside cleanliness in respect to oil and grease, and inspection to detect such small items as bits of packing or gloves. The incidence of such foreign matter in a nuclear plant is of far greater importance than the nuisance value in conventional power plants. Such standards should apply to valves, fittings, pipe, and other equipment located in primary and secondary circuits.

Construction standards are urgently needed for the recirculating air system in nuclear power plants, including methods for entry and exit from the containment vessels. This code should include tightness specifications for ventilating equipment handling radioactive gases and particles. Specifications for the piping, valves, fans, filters, installation, inspection, and maintenance are needed. Seals for doors into the ventilating system are needed. Specifications for the final air cleanliness at discharge are already available but have not yet been universally accepted.

The following are merely mentioned to indicate some needs for new standards and codes.

(*a*) Fire-fighting standards and equipment
(*b*) Standards for stand-by equipment such as pumps and auxiliary electrical supply
(*c*) Specifications for shielding grades of materials such as lead, polyethylene, and multipurpose materials such as high-boron steels
(*d*) Procedure for testing mechanical safety devices
(*e*) Standards for sampling methods and measuring the activity of radioactive wastes
(*f*) Standards for tanks and containment facilities for handling and transporting radioactive materials and wastes

Certainly, this is only a partial list of needed standards, primarily in the mechanical and civil-engineering fields. Other standards, for electrical insulation capable of withstanding effects of radiation, for new types of instrumentation, and many others are needed.

In certain other areas it is manifestly too early to prepare standards because of uncertainty in design and changing requirements. This is true of fabrication and processing standards for fuel-element assemblies, for instance. Looking ahead to the time when reactor fuels will contain uranium-233 or plutonium, a new set of problems will be encountered because of the toxicity, and pyrophoric nature of some plutonium alloys in particular. It is not too early, however, for appropriate committees to give preliminary consideration to these matters so that suitable standards can be developed promptly at the proper time.

Conclusions

Designs for several different types of power reactors are proceeding in this country, each with its own problems. Many problems, however, result from the basic process of fission of uranium which is common to all of the reactor concepts. Accordingly, in many areas, codes and standards can be developed which will be valuable to all.

In many cases, procedures, methods, and specifications have already been developed by the national laboratories and others so that adequate background information is available to amend existing codes and standards where available, or to develop new standards where needed. Existing committees, possibly augmented to include members familiar with the new technology, should be encouraged to do the job wherever possible.

Although the nuclear-energy technology is changing and will continue to do so for some time, it is believed that much codification and standards work can and should be done now before a multiplicity of individual standards and specification procedures results in chaos in the industry. This does not mean that atomic power plants cannot be built without such standards, as installations are now being designed and built. As more plants are built, however, the need for standards, codes, and specifications will become increasingly more important as atomic power takes its rightful place as a new energy source in order to produce safe and economic power.

The Design of Reactor Systems for Safety

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We are struggling with the exceedingly difficult problems of foreseeing and preventing a major reactor accident. There is the basic thought that a safe reactor and a reliable reactor are the same thing. Much remains to be done, but we are at least making a start on designing reactors for safety. With the full co-operation of technical men, whatever their discipline, we can move even faster.

THE extreme toxicity of the fission products and other radioactive substances generated in a reactor system makes it essential to avoid any accident which would lead to their release. The fact, that reactors have the ability to multiply their power level many thousands of times in a fraction of a second if control is lost,[2] means that there is a very real possibility of melting or vaporizing the fuel and disrupting the reactor container. This would provide a mechanism for the release of fission products. Obviously no cooling system can cope with such increases of performance. Moreover, even with the nuclear reaction shut off, cooling is required at an appreciable rate for some time in order to prevent the fuel from overheating and melting. A major reactor disaster would not only involve many people but also a very large amount of property damage.[3] In building a reactor which we feel is a safe and reliable one, we do *not* do this by hanging gadgets on some machine or other which shut it down on every pretext. But we do the job by thoroughly understanding the problems to be faced, and meeting them by designing the reactor to fit. It is far better to build inherent stability and reliability into the machine than to depend on gadgets no matter how clever they seem to be.

The stages of a reactor project may be stated as: conceptual design; start of design; start of construction; end of design; start of loading; and substantial end of construction; the point at which the reactor goes critical; full power; and reloading.

During the design and construction the theoretical knowledge of this reactor system and its hazards will be growing. There also will be extensive experimental and testing work. During this whole period the probability of a radioactive accident and the hazard to the public is strictly mathematically zero.

From the point where loading starts until criticality is approached, it rises sharply to its maximum when the reactor goes critical. In spite of all the calculations and the various critical experiments that have preceded this point there is the possibility of some unknown effect, mistakes in calculation, or an error in manipulation.

Once the reactor becomes critical, one checks out the dynamic behavior of the machine and once this is well understood the probability of accident decreases somewhat even though the power level is being pushed to its rated value. Once full power is reached, the dynamic behavior of the reactor under this condition is determined by actual operation. The supervisors and operators settle down to routine. The probability of accident drops sharply to its minimum value, and stays there until the uncertainties of reloading make a small increase for a short time. Each reloading will give some finite but decreasing bump to the accident-possibility curve. After the reactor has been in operation for some time, the curve will rise due to parts becoming old or worn and perhaps due to overconfidence on the part of operators.

Another part of the over-all problem is how the fission products build up. They are nonexistent up to the point where the reactor goes critical. They build up slowly to full power operation, then more rapidly, and finally taper off to a steady rise. There are decreases at the time of reloading, the amount depending on the amount of the core removed.

The potential hazard to the public is made up of fission-product inventory, probability of accident, and its probable severity in some complicated relation. This continues to rise more or less parallel with the fission-product build-up with a bobble at the reloading stage.

This is a rough picture of the safety problem of a reactor. If the job is done properly, the hazard to the public is well within the acceptable limit. The potentiality of accidents is largely dependent upon the skill with which we do the design and testing work. In general terms, safe design is possible because we deliberately attempt to foresee the ways in which the various parts of the reactor can fail, and take the necessary precaution against these failures so that they will not precipitate a major accident.

There are really two steps to this problem of reactor safety. One, the flux level of the reactor must be kept under control at all times. The point has already been made that a nuclear reactor is a dynamic thing which, if out of control, can increase in power level thousands of times in a fraction of a second. Continuous control is accomplished either by inherent design or necessary control elements, so the reactor can never start on one of these so-called transients. This is really a heat-transfer problem. The fission products are locked in a fuel element in the heterogeneous design or in a carefully contained solution of fissionable material in the homogeneous design, and the danger of a transient is that the

[1] Deputy Director for Hazards Evaluation.

[2] "The Safety of Nuclear Reactors," by C. Rogers McCullough, Mark M. Mills, and Edward Teller, paper 8/P/853, International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955.

[3] "Environmental Effects of a Major Reactor Disaster," by H. M. Parker and J. W. Healy, paper 8/P/482, International Conference on the Peaceful Uses of Atomic Energy, Geneva, Switzerland, 1955.

Condensed from the Nuclear Engineering Dinner Address, delivered at the Annual Meeting, New York, N. Y., Nov. 25-30, 1956, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

temperature rises so fast that we cannot remove the heat. The fuel element melts or vaporizes, the reactor is disrupted, and the dangerous fission products are released.

It should be pointed out that even when no accident occurs, the fuel elements may be damaged by the stresses which may be imposed by rapid changes in the flux level. This will, in turn, affect the long-range safety of the reactor.

The second point of importance is the necessity of maintaining the cooling in the reactor at all times. This can be broken into two parts, during normal operation and during the shutdown of the reactor. There are many problems of maintaining adequate cooling even during normal operation. The neutron flux peaks at various places and due to various conditions. These peaks may drift to different parts of the reactor depending on many factors. There are also transients of flux due to minor disturbances of the control system. The cooling must take care of all of these. If one is dealing with a very large core, as we usually are in a large power reactor, we have not only the over-all cooling of the core but these "hot-spot" problems which must be taken into consideration. For example, if we have a water-cooled reactor one must be careful that the hot spot does not lead to boiling and vaporization of the coolant, leaving that particular spot of the fuel element vapor blanketed. Under these conditions heat transfer would be very poor. If such a condition should develop, a burnout would likely occur. Worse, this might be a spreading disease and might finally involve a major portion of the core, if not kept under control.

The government requires that a license be obtained for the operation of an atomic-energy facility. This requirement is apparently based upon the theory that (1) security must be preserved where applicable; (2) the company planning a facility must have sufficient financial integrity to be able to be responsible for the fissionable material which is rented; and (3) the facility must be sufficiently well designed and operated so as not to endanger the health and safety of the public. At this stage of atomic energy the matter of judging the safety of an atomic-energy power facility is one of subjective judgment based on the data available. There are no generally applicable standards. It is important that we start the job of writing these standards while at the same time recognizing that standards and regulations should be fastened upon this new industry with great restraint and caution. In the design of reactors today we are probably imposing restrictions in many cases where they are really unnecessary, but they must be imposed at the present time, because of our ignorance as to their effect on the safe operation of the machine.

Nuclear Engineering—Where Do We Stand?

(*Continued from page 230*)

charge experiments, behavior of high-temperature discharges, and neutron production.

General Industrial Uses

Radiation and radioisotopes are being used in many industrial manufacturing processes as well as for special applications in research and development. Radioisotopes provide an important extension to the established techniques in radiographic inspection and nondestructive testing of materials and products. Practical and economically feasible applications of radioactive isotopes have been made for lubrication and wear studies, tracer techniques for the purpose of marking, instruments like the thickness gage for gaging and control, and ionization. Irradiation of materials before, during, or after chemical processing appears to have important possibilities.

Although the nuclear reactor is a source of heat, there appears to be "no immediately foreseeable economic advantage in the use of nuclear fuels for either space heating or process heating in applications where conventional fuels are now satisfactory" (10).

Summary

The feasibility of atomic power has been demonstrated. Much money and effort is still necessary to develop economically feasible and practical atomic power. Atomic power should "be exploited as a source of electric power at a rate consistent with sound technological, economic, and public-policy considerations" (11).

Many industrial applications are now practical and it is to be expected that the list will continue to grow rapidly.

Rapid advancement in nuclear technologies is also to be expected, making necessary a frequent re-evaluation of cost parameters and reserves of fossil fuels and of nuclear fuels. Although ownership of all special nuclear materials by the federal government is now desirable and useful, technical achievement and other developments may change at some time in the future, the factors motivating federal ownership.

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Radiation-Hazard Control for a Power Reactor

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The maximum permissible occupational exposure recommended by the National Committee on Radiation Protection is 0.3 roentgen per week. At this level, exposure throughout a work lifetime can mean a 3-year reduction in life span, and unknown genetic consequences to future generations through mutation effects.

The author recommends adoption of one-tenth that level, or 0.03 r per week, as a maximum design standard. Life-span reduction at most would be only four months, and off-site hazards would be negligible.

THIS paper treats the general problems of radiation-hazard control for a power reactor. Inevitably, discussion of the potential hazards of a new industry gives an impression of new, unknown, and terrifying dangers. Actually, radiation hazards are neither new nor unknown and the safety record of the Manhattan Project, the AEC, and their many contractors is proof that adequate control of these hazards is possible.

Maximum Permissible Exposure

The maximum permissible occupational exposure recommended by the National Committee on Radiation Protection is 0.3 roentgen per week (1).[2] The Committee makes it clear that the concept of a maximum permissible exposure does not entirely preclude the *possibility* of a radiation injury to the exposed individual or to succeeding generations. It is the intent, however, that the *probability* of the occurrence of such injuries should be so low that the risk will be readily acceptable to the average individual. How great is this risk, and how does it compare with the ordinary risks of life?

Repeated small doses of radiation appear to reduce the life expectancy of experimental animals by an amount directly proportional to the total dose (2). The results of this type of experiment are illustrated in Fig. 1. The fractional life-span shortening per roentgen appears to be relatively constant among the various species of animals, at perhaps 1 per cent per 100 roentgens (2). It is important to note that individuals in the irradiated group die, in general, from the same causes as do the individuals in the control group; the difference is that they die a little sooner. It is impossible to assign radiation as the cause of death in any individual case.

An individual who receives the maximum permissible exposure of 0.3 r each week will accumulate a total dose of 450 r in 30 years. Extrapolation of the available life-span-shortening data suggests that this dose will reduce the life expectancy of the exposed individual about three years. Life insurance statistics show that the life expectancy of the average 30-year-old white male in the United States is reduced 0.9 year by accidents of all kinds, and 1.8 years by cancer (3). Thus the risk involved in a working lifetime at the exposure rate of 0.3 r per week is great enough to warrant some effort to reduce it. If the occupational exposure can be limited to $^1/_{10}$ the recommended value, i.e., to 0.03 r per week, the life-expectancy reduction from a lifetime of work will be about four months, a risk acceptable to most people.

Radiation applied to the reproductive cells of living organisms induces changes in the genetic material of these cells. The number of these changes is in direct proportion to the amount of the dose. Genetic changes of this sort are usually detrimental. It is estimated that a dose of between 30 and 80 r to every individual parent in one generation will double the mutation burden in the next generation (4). The risk of genetic mutations is not to the individual who receives the radiation, but to his children and to succeeding generations.

A number of installations have adopted one tenth the maximum permissible exposure recommended by the National Committee on Radiation Protection, or 0.03 r per week, as a working criterion, and every reasonable

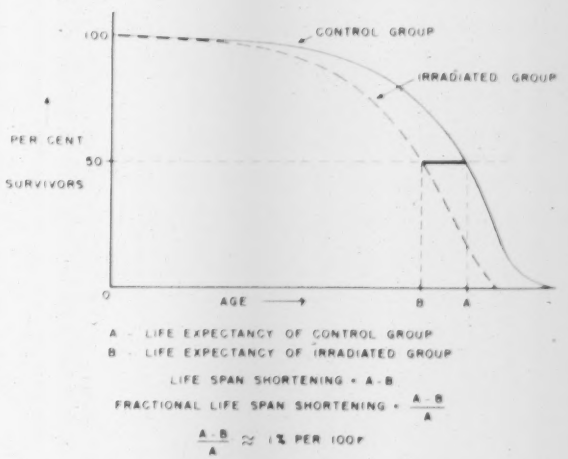

Fig. 1 Typical results of an experiment on the life-span shortening produced by radiation

[1] Health Physics Consultant to Atomic Power Development Associates, Inc., Detroit, Mich.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

Contributed by the Nuclear Engineering Division ASME, and presented at the Nuclear Engineering and Science Congress, Cleveland, Ohio, December, 1955.

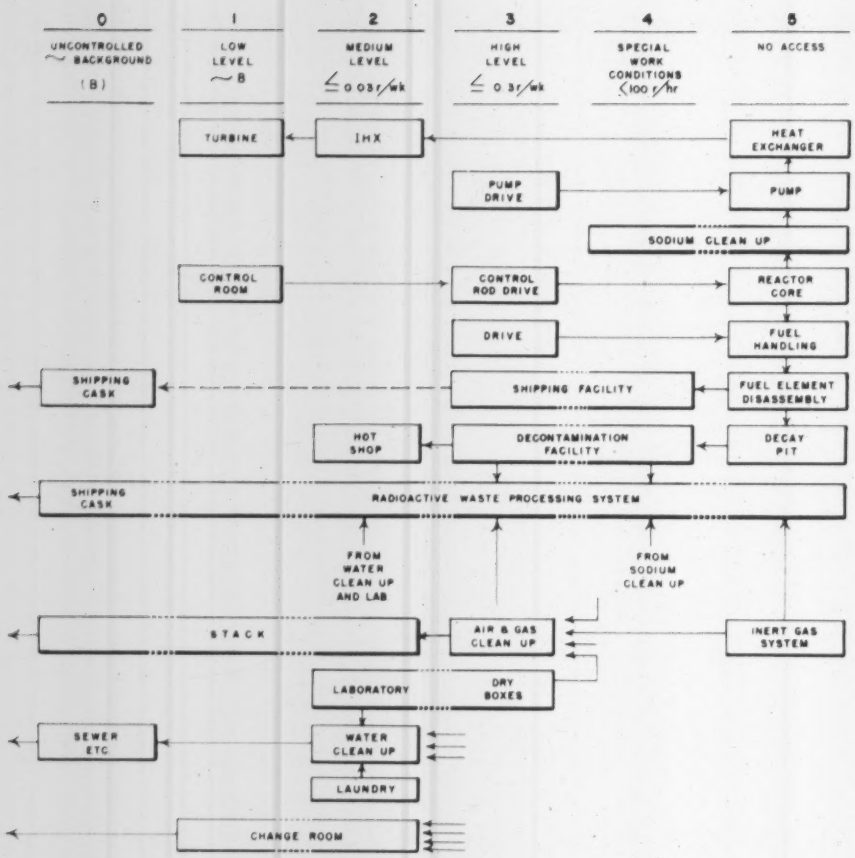

Fig. 2 Relations among representative sources of radiation and contamination in a power reactor plant

effort is made to reduce the average exposure below this. As an example of the results of this effort, the average exposure to all Hanford and Oak Ridge workers during 1949 was 0.004 r per week, which amounts to little more than double the dose received from cosmic radiation and natural radioactive materials (5).

The Sources of Radiation Hazard in a Reactor Power Plant

Sources of radiation to which workers in a nuclear power plant may be exposed are shown in Fig. 2. The sources of radiation are arranged in this figure according to the level of hazard, and some of the functional relations among the various components are shown. Control of radiation hazards begins with the recognition of the various sources of radiation and an estimation of the radiation level expected from each source. The next step is the maintenance of the differentials between the various levels.

Operation of the plant requires that materials and men pass from one hazard level to another. Hazard differentials are maintained by shielding, by air flow in the proper direction at an adequate rate, by decontamination, by packaging, and by continual monitoring with radiation instruments.

It is important to distinguish between radiation and contamination. A given amount of radioactive material is considerably less hazardous when it is fixed than when it is free to move about. The hazard from fixed radioactive materials is that of external radiation, usually only the gamma radiation when the material is enclosed.

Once radioactive material becomes loose, the possibility of its getting into the body by inhaling, drinking, eating, or by other means arises, and the potential hazard is that of radioactive material lodged inside the body. Radiation from a fixed source is controlled by shielding, distance, and/or time of exposure. Control of loose radioactive material is considerably more difficult because of its propensity to move about and to become air-borne.

Throughout a plant and particularly where people, materials, gases, and so on pass across boundaries between different levels, there will be radiation-monitoring instruments to check on the adequacy of the control. Workers will wear one or more types of radiation-monitoring instruments so that a continuing record of the radiation exposure can be kept for each employee. Hours of work in the higher levels will be regulated and all workers will be subjected to careful periodic medical checks, including assay of the amounts of radioactive material which they may have acquired in their bodies. To sum up, all areas within the plant must be controlled.

Air, water, and other materials leaving the plant pass into an uncontrolled area. Beyond the plant fence no one wears a film badge, submits a urine sample, or follows prescribed procedures. Microorganisms concentrate radioactive wastes from waste water; fish eat the microorganisms; people eat the fish. With the exception of carefully prepared shipments, materials which enter the public domain can no longer be controlled. For this reason no discharge of activity in excess of permissible levels to the public domain must occur.

The differences between the controlled areas within the plant and the uncontrolled areas which lie everywhere outside the plant give rise to what appears to be a double standard of safety. It is common to limit the exposure for people outside the radioactive installation to $^1/_{10}$ of that allowed people working in the plant (6, 7). It would seem from this that one intended to be ten times as careful with his neighbors as with his employees. Actually this is not the case. One's neighbor can remain in his house for 168 hours a week, but it is unusual for a worker to be in the plant more than 40 hours a week; one's neighborhood may include pregnant women (pregnant women are almost universally excluded from radiation work); finally, and most important, is the complete absence of control outside the plant.

It is true that off-site surveys will be made of air, water, vegetation, and other items as a check on the performance of the various clean-up systems, but this does not constitute control in the sense that it applies within the plant.

Factors in Plant Design

Shielding. It is sufficient here to point out that shields adequate to attenuate gamma and neutron radiation by factors of 10^{-10} to 10^{-14} are required for power reactors, and that shields of this magnitude cannot be designed with a slide rule or a desk calculator. Good design is a necessary but not a sufficient condition for an adequate shield. Voids and uneven distribution of the aggregate can reduce the effectiveness of a shield considerably, and meticulous control during fabrication is important, particularly with the special heavy concretes.

Ventilation. The general rule for good ventilation practice in radioactive installations is that air flows from areas of lower to areas of higher activity, as illustrated in Fig. 3. To accomplish this, the exhaust must be from the area of highest activity. Two factors may prevent the application of this simple rule to the ventilation of the entire nuclear power plant. The first of these is that the area of highest activity, the reactor itself, is so enormously active that it is not economic to clean an appreciable volume of air for release to the atmosphere. The reactor gas system will in general contain vapors, particulates, and radioactive noble gases in concentrations that require a clean-up system of traps and filters with a transmission factor of 10^{-6} to 10^{-10} in order to permit release to the atmosphere. The expense of processing large volumes of gas in a clean-up system of this excellence will obviously be very great.

The other factor which may prevent the simple one-directional air flow in a power-reactor building is the necessity for keeping oxygen, nitrogen, and water vapor away from the reactor core, particularly in the case of sodium-cooled reactors.

The necessity for maintaining an inert atmosphere in the primary reactor housing, the fact that the activity is so very high inside the reactor that a single gas barrier cannot be trusted, and the high cost of cleaning heavily contaminated gas, all dictate a somewhat more complex gas-control system than is adequate in simpler radioactive installations. Such a system is shown in Fig. 4.

The innermost region represents the inert gas over the sodium which passes through the reactor core. This region is shown completely surrounded by an inert gas at a somewhat higher pressure than that over the sodium. The second region, in turn, is completely surrounded by an atmosphere, possibly depleted in oxygen, at a pressure lower than either that of the region which it encloses or that of atmospheric air. As long as the pressure profile shown in Fig. 4 is maintained, no radioactive material can leak out of the reactor-core system, and no oxygen or water vapor can leak into the core.

Plant Layout. Radiation-hazard control imposes several requirements in addition to those normally considered in plant layout. It is frequently possible to reduce both shielding and ventilation costs by arranging the areas of

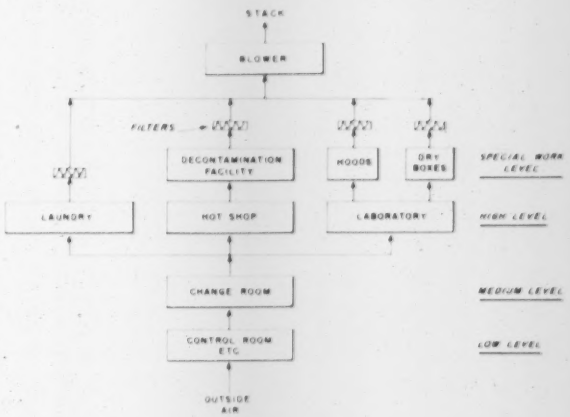

Fig. 3 Ventilation by flow from areas of lower activity to areas of higher activity

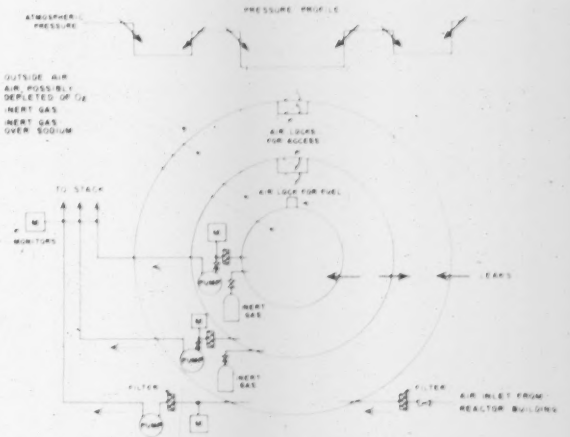

Fig. 4 Schematic of a possible gas-control system for a reactor

different hazard levels into concentric zones with those of highest activity in the center.

A third factor which must be considered in the plant layout is the flow pattern of plant personnel in the performance of their duties. The most effective arrangement is usually that where the workers enter at the lowest level and pass to areas of successively higher levels. Work in the higher levels will require one or another kind of protective equipment: overalls, boots, gloves, respirators, supplied air masks, and so on. A man leaving such an area requires the services of a change room, where he can remove and dispose of his protective equipment, check his body for contamination, and decontaminate himself or receive assistance in decontaminating himself.

Economies can be effected by grouping areas of similar hazard level in such a way that all potentially contaminated workers can use a single change room with the shortest possible distance of travel. The optimum arrangement for worker traffic requires careful analysis of the work which is to be done in the contaminated areas and appreciation of the fact that convenience in doing such work is not a luxury, but a continuing source of savings in the operation of the plant. Consideration should be given both to routine service and inspection and to special repair and replacement work.

Materials. The choice of construction materials has a considerable effect on the radiation hazards in the plant. The radioactivity induced in most elements by neutron capture introduces a new factor into the selection of materials which will be subjected to neutron fields. Pure aluminum, for example, is a desirable material from this standpoint because the activity induced by neutron capture dies away with a 2.3-minute half-life. In the reconstruction of the Chalk River NRX reactor a stainless-steel shield disk was replaced by an aluminum disk. The shielding properties of aluminum are inferior to those of stainless steel, but the induced activity decays away so much more rapidly that any future repair will be greatly facilitated.

Impurities, or elements which occur in small quantities can be surprisingly troublesome after neutron irradiation. For the first few hours after removal from the reactor the major part of the radiation from 304-stainless comes from the 1 per cent manganese in the steel, but after a few months the radiation from the 0.1 per cent of cobalt contributes the major part.

As a final example of the subtleties of neutron-induced activities, it is worth mentioning the tritium produced in heavy water. Tritium is a particularly difficult material to detect, measure, and control. The hazard from tritium is not that of external radiation, but of inhalation, ingestion, and absorption.

The choice of surface finishes is also an important factor. The ease of decontamination varies greatly with the nature of the surface. Rough, porous surfaces are difficult to free of contamination. Unpainted concrete is particularly troublesome in this respect. The resistance of surface finishes to harsh decontamination procedures is also important.

Flexibility. Wherever large quantities of radioactive materials are involved it is extremely important to make allowances for the unexpected. Perhaps the best provision for the unforeseeable is to design into the plant as much flexibility as possible, in order to provide for expansion, changes, errors in design and construction, and to permit recovery from accidents. Where a large amount of radiation is involved, repair and replacement operations can be very difficult unless reasonable working times are possible.

Factors in Plant Operation

Personnel Training. The single most important factor in the control of radiation hazards in a power plant is the attitude of everyone in the plant, from top to bottom. Careful selection will be necessary to obtain people who are equal to the responsibilities of working in the plant. Painstaking instruction in the hazards of radiation and in the protective methods and devices necessary to work safely in the plant are essential parts of the training given these men. The accident-prone, the worriers, the overconfident must be educated, or eliminated, if the plant is to be operated with a minimum risk to everyone.

Protective Equipment. Work in contaminated areas, in the presence of appreciable quantities of air-borne radioactivity, and in inert atmospheres requires personnel-protective equipment. There is a bewildering array of this type of equipment in use, and it would seem that the opportunity for new designs must be nearly exhausted.

The proper use, maintenance, and test of the protective equipment are operations of some importance. The services of a small laundry equipped specifically to decontaminate the clothing and other protective equipment are required.

Radiation Instruments. Gamma, beta, and neutron radiation presents potential hazard in a nuclear power plant. In most cases, alpha radiation will present no problem. None of the five senses responds to these radiations, so it is necessary to have instruments which can detect and measure them. Radiation instruments are needed for a number of purposes:

1 To observe the radiation levels at key locations in order to check on the performance of shields, filters, traps, decontamination procedures, etc.

2 To determine safe working times, and to warn that entry is unsafe.

3 To detect and locate contamination on personnel, equipment, and in the building.

4 To detect radioactivity in the plant air.

5 To measure the exposure received by each individual.

6 To monitor all materials before release: air, water, equipment, casks, etc.

7 To monitor off-site conditions (air, water, surfaces, etc.) as a final check on plant control.

The calibration, maintenance, and repair of radiation instruments present certain problems in that special technical skills and special facilities are required. Whether these services should be provided by the reactor plant, or by an outside laboratory specializing in radiation instruments is a question of economics and efficiency.

Personnel Monitoring. The radiation instruments needed to monitor the individual exposure of each worker in the plant have already been mentioned. In addition to these physical measurements of radiation exposure, certain biological measurements will be made. The most useful of these is the periodic analysis of the urine for radioactivity. This analysis reveals the presence of any significant amounts of radioactive material which have entered a worker's body by inhalation, ingestion, or skin absorption. Blood counts and the regular medi-

cal examination will also be used to observe the general health of the worker, but conventional medical tests appear to be of limited value in regulating exposure at, or below, an exposure level of 0.3 r per week.

The permanent record of the exposure and biological data for each plant worker is an important and useful body of information. It is required by some state laws (7, 8), and will eventually be required by the AEC (6). Apart from their legal importance, these records will be useful in plant operation. Unsuspected conditions will be revealed; careless workers and inadequate supervision will be apparent; and morale will be improved by the confidence which a good personnel-monitoring system produces.

Waste Disposal. Radioactive wastes from a power plant will be handled in three ways: (*a*) Low-activity liquids and gases will be diluted and released; (*b*) high-activity materials will be packaged and shipped away; and (*c*) material with high-level short-lived activity will be stored to allow decay. It should be noted that none of these methods follows the radioactive wastes from power reactors to their final resting place and that the question of the ultimate disposal of these wastes has not been answered (9).

Off-Site Monitoring. The final check on the excellence of the control of radioactive materials in the plant will be obtained by measurements in the environment surrounding the plant. This off-site monitoring will include measurements of air-borne radioactivity concentrations, concentrations in sewers or rivers, fall out density on the ground and vegetation, and stray radiation intensities. Some of these measurements will be made continuously, some periodically, and some only occasionally. They may be made by the plant organization, by the local public-health authorities, or by some commercial agency.

This monitoring will have great public-relations value, quite apart from its importance to health and safety. Measurements of this kind must be made for some time before the plant goes into operation to provide background data on the surroundings, otherwise every radioactive disintegration in the vicinity will be attributed to the operation of the plant.

Some Economic Aspects of Radiation Control

The control of radiation hazard will add significantly to the total cost of building and operating a nuclear power plant. The cost of designed-in control and safety must be evaluated in terms of the savings they will permit in operating costs. Construction costs are paid only once, but operating costs will be paid throughout the life of the plant.

Suppose that a piece of equipment has failed in an area of high radiation levels, and that replacement of the equipment requires two man-hours of work in an area where the radiation level is 10 r per hr. Suppose also that the policy for special work conditions in the plant permits a man to receive up to 2 r in a single exposure, provided that he is removed from radiation exposure for a period of 13 weeks. Under these conditions the replacement job can be done with a minimum of 10 men, each receiving 2 r in a 12-minute work period. For the next 13 weeks these 10 men will be excluded from radiation work. If there is no radiation-free work in the plant for these men to do, the cost of the replacement job can be as high as $2^1/_2$ man-years.

Proper plant design will reduce the frequency at which failures in high-radiation areas occur; it will reduce both the time and dose rates required to make these replacements; and, finally, proper plant design will keep a large portion of the plant at sufficiently low-radiation levels to permit radiation-free work by men who have received special work exposures.

Another economic aspect of radiation control which should be considered is legislation. Many states are considering legislation for the regulation of radioactive materials. The possibility that the present maximum permissible exposure levels may be reduced (10) must also be considered. Failure to take these factors into account in designing the plant may make the plant operation very cumbersome if and when such regulations are put into effect.

Conclusions

1 The recommended maximum permissible exposure of 0.3 r per week has a small but possibly significant risk for a lifetime occupational exposure.

2 It has been demonstrated that reactor plants can be designed and operated with an average level considerably less than 0.3 r per week.

3 The additional cost of a reactor plant designed for average exposure levels less than 0.3 r per week will probably be recovered many times over by savings in operating costs.

4 In keeping with good engineering practice, which always includes a safety factor in any design, it is recommended that 0.03 r per week be taken as the design criterion.

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The Use of Atomic Energy in the Testing of Materials

Inexpensive radioisotopes offer many possibilities for nondestructive inspection

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EVER since the engineering art developed castings, large rolled sections, forgings, and weldments, it has been the goal of quality-control personnel in production plants to explore thoroughly the interior of metal sections without destroying or damaging them. With the discovery of the x ray, a new concept in interior examination unfolded. So long as it was possible to pass electromagnetic radiation of different wave lengths through what are generally considered solid materials, it remained only to interpret the rays after they passed through the material under scrutiny. At the beginning the x ray was used primarily for medical investigation; but later, when more powerful x rays were developed, it was found that the same principle could be applied to thick metal parts.

The use of x rays produced by electrical vacuum tubes has limitations. The equipment for a million-volt x-ray machine is quite large and unwieldy, and represents a rather large investment. Consequently, when radioactive materials became more generally available, they were used to provide a cheap and convenient source of rays that could be used in testing materials.

Isotopes for Testing

A quantity of cobalt-60 costing $125 is equivalent as an energy source of gamma rays to more than $15,000 worth of radium, or a ratio in cost of 120 to 1, and less than 1 per cent of the comparable gamma-ray equivalent of radium.

Wide Field of Usefulness. The radiations emitted by natural radioactive elements are traditionally designated as alpha, beta, and gamma rays. The first two types are constituted by particles and the third one is of the nature of an electromagnetic wave. There has been some confusion about x rays and gamma rays. Owing to the fact that until recently high-voltage x-ray machines were not available, the opinion existed in some quarters that x rays were less powerful than gamma rays. Actually, they are similar in nature, being radiant electromagnetic energy. For that matter they are similar to light or radio waves, their difference in behavior being due only to their much higher energy. The difference between gamma and x rays resides in their origin; the former originate in nuclear processes, while x rays are produced by the retardation of electrons, which is an extranuclear process. Of course, one may have very "soft" gamma rays and very "hard" x rays. For instance, with the modern machines, 5 Mev (million electron volts) x rays can be produced, while thulium 170 emits 84 kv (thousands of electron volts) gamma rays. The only difference is in the mode of creation.

Alpha, Beta, and Gamma Rays. Alpha rays, or alpha particles, are emitted from decaying radioisotopes at energy levels as high as 10 Mev with a charge of two positive electrons. Their low penetrating power makes them useless for inspecting metals, and at energy levels less than 7.5 Mev they will not even penetrate the skin of the human body.

Beta rays, or beta particles, emitted from radioactive materials, are identical to electrons, and lose energy when passing through materials by the emission of electromagnetic radiation known as "braking radiation." This is more dangerous to humans than the primary radiation, but can be shielded by small thicknesses of solid materials, consequently such rays are ineffective for exploring heavy metal sections.

Gamma rays, or x rays, indistinguishable from one another in behavior, are of slightly longer wave length, and very penetrating, hence effective for use in testing materials.

In passing through materials, gamma rays lose their energy by interaction with electrons. Where the magnitudes in Mev are sufficient, the penetration of these rays is great enough to permit the development of film placed against several inches of steel.

The Southern Pacific Company has used both radium and cobalt-60 to examine castings. The radium used provided an output of 200 millicurie and was on a rental basis of $600 per year. The energy source was later replaced with a 620-millicurie cobalt-60 source, obtained from the AEC at a cost of only $125 f.o.b. Oak Ridge. Since the half life on cobalt-60 is 5 years, it becomes apparent that the use of this medium is very economical.

Precautions to Prevent Injury of Personnel

Reasonable precautions must be taken to protect personnel from radiation injury. Fig. 1 shows the storing location for the cobalt-60 source used by the Southern Pacific Company which, while simple, forms an effective way to store this material safely. Storage of radioactive materials probably presents the least troublesome problems involved in the use of such materials. The principal dangers are encountered while the process of inspection is under way.

The most satisfactory means of keeping a check on the exposure to which personnel have been subjected are the film badge and ionization-type pencil. Proper check of these devices provides a suitable monitoring system which will reliably indicate the exposure to which persons have been subjected.

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Fig. 1 Storing location for cobalt-60 source, as used by the Southern Pacific Company

If a large amount of radiographic work is to be performed which requires a group of technicians, the laboratory where this work is done should designate some qualified person to be responsible for the use, storage, and records of isotopes or other radioactive materials in use. This person also should keep records of physical examinations made of all those engaged in the work and of the various dosimeters in use.

Unusual personal cleanliness should be stressed. Hands, arms, and face should be washed with soap and water before leaving the laboratory or place where the work is done each time a person is exposed.

Buildings and locations in which radioactive materials are used must be posted as hazardous areas as required by law.

Penetration of Gamma Rays

It has been found on the Southern Pacific that a section of steel 1 in. thick requires 16 hr exposure when a gamma-ray source placed at 6 ft from the plate delivers 900 milliroentgens to the plate. Obviously this time is too long for the use of this means of testing as a production tool, and study and experience will be required to reduce the time necessary for satisfactory radiographs if any great extension is to be made of the use of this valuable tool.

More recent data for cobalt-60 indicate that a relatively modest-sized source ($^1/_2$ curie), at the daily cost of $1.85 (8-hr day) can produce 18 exposures for 1-in-thick pieces of steel, using medium-speed film.[1]

Use of Radioactive Materials on Railroads

The Southern Pacific Company has successfully used both radium and cobalt-60 to produce radiographs. The judgment of the operator is the best guide in obtaining the angle and distance from the energy source best suited for the location of the part under examination. The greater the distance from the material, the sharper will be the outlines of blowholes, cavities, and other discontinuities. Here again experience improves the quality of the work produced. However, the time required for film exposure is important.

Films are usually taped to the section being tested. X-ray films in cassette envelopes are used and lead foil is placed against both sides of the film to reduce the exposure time required. The lead foil produces secondary electrons by the incident gamma rays, which have a greater developing effect than the gamma rays themselves and thereby reduces the exposure time required.

A number of complicated railroad-equipment sections have been tested successfully by the use of gamma or x rays. The coupler yoke which is a heavy section, as is evident from Fig. 2, has been subjected to such tests with satisfactory results. However, this part of the car is relatively simple in configuration when compared with such parts as the car-truck side casting or coupler shown in Figs. 3 and 4. The problem of obtaining radiographs of these parts in their entirety is evident from the irregular shape of the sections. The manipulation of the gamma-ray source and the application of film are a complicated procedure on parts of this shape, and the time required to obtain radiographs would result in excessive expense.

Quick Inspection Required. Because of the critical function of certain car parts it would be helpful if a quick means of inspection could be made while cars are undergoing repairs.

These parts include wheels, axles, brake beams, truck side frames, truck bolsters, couplers, coupler yokes.

Wheels can be inspected with gamma rays with relative ease. However, the area of surface requiring inspection is large. Because of this, film expense is high. The time required to obtain suitable pictures and the film cost present economic problems.

Axles are of simple cylindrical shape and would be ideal subjects for radiographs if it were not for the thickness of sections. A $6^1/_2 \times 12$-in. axle has a wheel seat $8^1/_8$-in. diam and this large section presents a problem in time as well as the expense involved in developing a satisfactory radiograph. Also the definition on radiographs would be required to be extremely sharp since a crack which is only $^1/_{32}$ in. or less deep should be detected as well as the larger defects if this system of inspection were to be considered acceptable.

Axle Inspection. Axles are handled in wheel shops under production conditions. If it were possible to inspect an area by radiology at a rate of one axle per hr, perhaps a flexible means of adding a number of axles to the shop stock would prevent delay in the production line. It is obvious that any inspection must be made in such a way as to detect any defects present before wheels or bearings are mounted on axles. Therefore, any axles which are under examination must be considered quarantined until the results of the inspection are known.

Brake Beams. Brake beams are irregular in shape and, because of this fact, problems are involved in obtaining revealing radiographs. Moreover, the method of repairing brake beams is such as to make the introduction of this method of testing difficult. At present, most brake-beam-parts inspection is confined to visual examination. Except for special examinations, it is doubt-

[1] "Industrial Inspection with Reactor Isotopes," by E. J. Clarke, Proceedings of the International Conference on Peaceful Uses of Atomic Energy, vol. 15, 1956, p. 188.

ful whether it would be economically feasible to inspect brake beams by radiographs.

Truck Side Frames. Truck side frames and bolsters, because of the irregular shape of sections, present a difficult problem in locating the energy source and attaching film to the areas to be inspected. The principal parts of trucks under major stress are the truss members, and failures in these parts may permit truck parts to drop to the rail. The geometry of the truss is such that even though these members were the only parts inspected, an expensive procedure would be required. Truck bolsters are not a frequent source of failure, but if a simple and reliable means of inspection for cracks and defects could be developed it would be put to use. In this case, the extravagant use of film and time appears at present to be a barrier to using this means of inspection on a production basis.

Couplers. Inspection of couplers and coupler yokes by radiology is perhaps the most promising field in which to start this means of inspection. These parts are vital to train operation and are under continual stress in train movement at a comparatively high level. Because of the size and shape of such parts, the problems involved in locating the energy source and applying the film are not as complicated as in some of the other parts discussed previously.

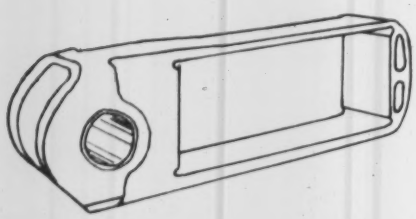


Fig. 2 Configuration of a railroad coupler yoke. The thickness of the casting requires high penetration.

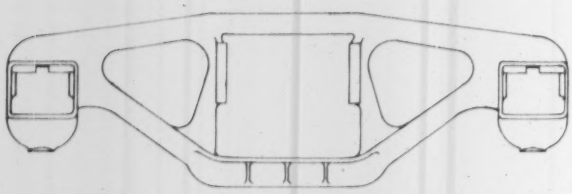


Fig. 3 Railroad freight-car truck-side-frame casting is another part that is difficult to x ray because of thickness

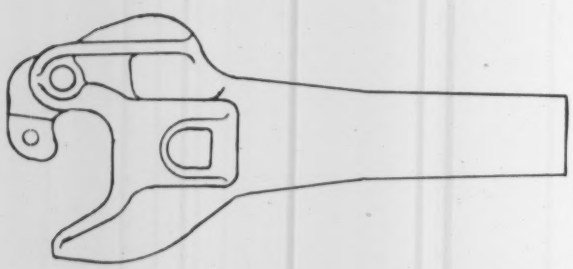


Fig. 4 Contour of railroad-car coupler, a part in which failure is costly

Inspecting Welds. One application where gamma-ray inspection is likely to increase is in the radiographing of electric welds on critical parts. The radiographing of welded boiler barrels was important some 15 or 20 years ago when welded boilers were designed. However, the steam locomotive is disappearing at a rapid rate and boilers are no longer of critical interest. A similar application of this principle is the radiographic examination of welds in tank cars. It appears that the use of welded tank cars will increase. The juncture of the tank heads and the cylinder on such cars are being tested in this manner to insure satisfactory welds. In this case only the weld area is examined as the rolled plates which form the barrel and the tank heads are of uniform quality not requiring such examination. Since tank cars are subjected to relatively high pressures and since they carry corrosive and sometimes hazardous cargoes it is important that welded tanks be inspected carefully.

In the foregoing discussion, many difficulties in using gamma-ray inspection are considered. History shows that the early methods of using new principles in engineering are superseded by advances in the art. It is very likely that further development of gamma-ray inspection will eliminate some of the barriers presented in this discussion; gamma-ray inspection of materials will advance from the limited use now enjoyed into a production tool. At present the two limiting factors of most serious consequence are time of exposure and the cost of film with the attendant expense of development and analysis. It is likely that a cheaper film with an increase in power of gamma-ray output will begin to move the use of the radiograph on railroads into a device of more general utility.

Use of Isotopes in Railroad Testing

Several railroads are experimenting with isotopes in diesel engines, as a means of following the rates of wear and the study of oil distribution. One railroad is conducting a project with the twofold purpose of developing the techniques of using isotopes and obtaining wear on engine piston rings and cylinder liners, and to accelerate diesel-engine air-intake filter tests. Another railroad is investigating wrist-pin wear by making radioactive test parts.

A great many problems are involved in developing standard outlines of procedure appropriate for railroad use of this new technique. Suitable precautions must be used to avoid the unnecessary presence of personnel in areas which might be considered hazardous. Care must be exercised in obtaining oil samples to insure that they are representative of the entire crank case. Careful records must be kept to insure accurate conclusions.

At this time, standard procedures for railroad use of atomic energy in testing are not yet perfected. The progress of this development probably will not be rapid because of the complications inherent in the problems involved. However, the possibilities of atomic energy in its various sources are so attractive that new uses will be suggested automatically.

As an experimental and exploratory means of investigating sections, the gamma ray is now a valuable tool. It is not difficult to use properly and, with relatively brief experience, personnel become proficient in developing valuable data.

Neutron Radiation Effects on . . .

. . . Tensile and Impact Properties of ASTM-A302 B Steel

By E. E. Baldwin, Engineer, Knolls Atomic Power Laboratory
General Electric Company, Schenectady, N. Y.

With the use of high-yield-strength low-alloy steels for nuclear-reactor pressure vessels, it is important to know whether the operating conditions of temperature and radiation will affect the mechanical properties of these steels and the magnitude of such effects. Tensile and impact specimens of ASTM-A302-51T Grade B manganese-molybdenum steel were fabricated, canned, charged into the Brookhaven reactor, and irradiated to a calculated integrated fast-neutron flux of 3.7×10^{18} nvt at 500 and 700 F. Comparison of tensile and impact-test data on irradiated and unirradiated specimens showed that the separate and combined effects of temperature and radiation had only minor effects (less than 10 per cent) upon the tensile and impact properties of the steel tested.

SEVERAL power-producing nuclear reactors have been designed and built using pressurized water as a coolant. In each of these power plants, the reactor is installed in a pressure vessel which is fabricated of ASTM-A212 carbon-silicon steel.

One step toward improving the design of pressurized-water power reactors, especially those which are part of mobile power plants, is a reduction in the plant weight, or increase in the horsepower-to-weight ratio. One method by which this reduction can be made is by reducing the weight of the plant without reducing the power, which is accomplished by using a steel with higher-strength properties for the reactor pressure vessel. When the weight is reduced by reducing the thickness of the pressure vessel a second advantage is realized by concurrent reduction of the thermal stresses in the pressure-vessel wall.

All reactor pressure vessels are subjected to elevated temperatures and neutron radiation, and these have an effect on the mechanical properties of steel with increased exposure. Manganese-molybdenum steel, ASTM-A302 B, has mechanical properties which are higher than ASTM-A212 steel, and if these properties were not seriously affected by elevated operating temperatures and neutron irradiation, it might serve as a means of attaining the improved reduction in plant weight, increased horsepower-to-weight ratio, and reduced thermal stresses.

Contributed by the Metals Engineering Division and presented at the Annual Meeting, New York, N. Y., Nov. 25–30, 1956, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. ASME Paper No. 56—A-107.

Purpose of Investigation

This investigation was conducted to determine the effect of elevated temperature and neutron radiation upon the tensile and impact strength of ASTM-A302 steel. The results also served to indicate the effect the operating conditions of temperature and radiation had upon the tensile and impact strengths of the structural material to be used for pressurized-water-reactor pressure vessels.

Description of Material. The material used in this investigation was manganese-molybdenum firebox steel manufactured to ASTM Specification A 302-52T, Grade B, in the form of cross-rolled plate $2^1/_2$ in. thick and having the composition listed in Table 1.

Table 1 Chemical Composition of Steel Tested

C	Mn	P	S	Si	Mo
0.25	1.38	0.016	0.034	0.24	0.45

The plate was normalized at 1650–1700 F (900–927 C) for one hour per in. of thickness and air-cooled after rolling. Prior to fabrication of the specimens, the plate was cut into slabs 12 in. sq, and these slabs were annealed for $2^1/_2$ hr at 1250 F (677 C) and air-cooled. The microstructure of the steel in the normalized and stress-relieved condition was a mixture of ferrite and Bainite, and had a grain size of ASTM-8.

Specimens. The specimens machined from the steel under investigation were designed so that they could be tested after irradiation in the equipment available in the Radioactive Materials Laboratory at the Knolls Atomic Power Laboratory. Specimens for tensile tests were in the form of button-head specimens in Fig. 1 and impact strength was investigated with standard Charpy V-notch impact specimens in a Sonntag impact tester.

All specimens were machined with their longitudinal axis parallel with the final rolling direction of the plate, and at a depth from the surface approximately equal to one fourth of the plate thickness.

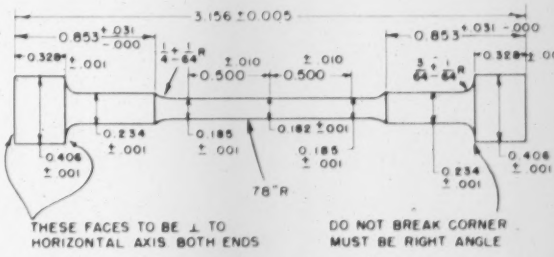


Fig. 1 The tensile specimen was finish-ground all over except the ends to an f-16 finish, and center holes were removed after finish-machining

Irradiation Equipment. For the irradiation tests, four tensile and 16 impact specimens were assembled into aluminum slugs of two types. Two tensile and four impact specimens were contained in Type 1, Fig. 2, and Type 2 contained eight impact specimens, Fig. 3. Two Type-1 slugs and one Type-2 slug were connected to each other by $^1/_2$-in-diam aluminum tubing, forming a complete slug assembly.

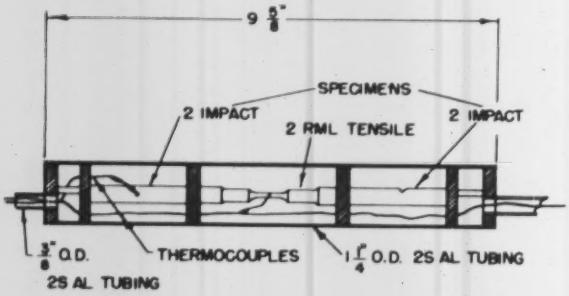


Fig. 2 Pressure vessel steel irradiation slug Type 1 included two tensile and four impact specimens

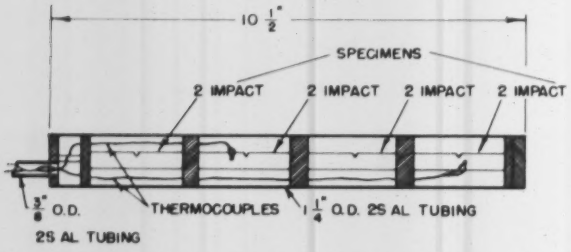


Fig. 3 Pressure vessel steel irradiation slug Type 2 included eight impact specimens

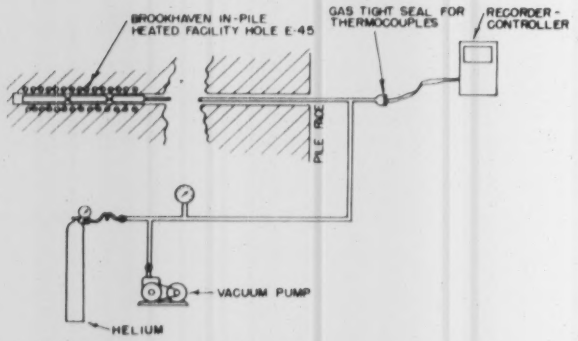


Fig. 4 Pressure vessel steel irradiation in-pile and out-of-pile facilities

Chromel-alumel thermocouples were attached with carbon-steel wire to six specimens along the length of each slug assembly, and were used for measurement and control of temperature during irradiation.

The assembled irradiation slug and associated equipment consisted of one slug assembly, to which was attached $^3/_8$-in-diam aluminum tubing extending out of the pile. This tubing contained the thermocouple leads and was used to evacuate the slug assembly and fill it with helium during irradiation. The thermocouples were attached to a temperature controller and recorder, and the tubing was fastened to vacuum and helium lines, Fig. 4. After irradiation each slug assembly was cut into its separate parts, Fig. 5.

Irradiation Conditions. Two slug assemblies were assembled and irradiated for 20 days to a calculated integrated fast-neutron flux of approximately 3.7×10^{18} nvt in the heated test facility of the Brookhaven reactor. One slug assembly was irradiated at a temperature of 500 ± 35 F (260 ± 20 C), and the second slug assembly was irradiated at a temperature of 700 ± 25 F (371 ± 14 C). Plots of temperature versus time in the pile are shown in Figs. 6 and 7.

To determine the effect temperature alone might have on the mechanical properties of the steel under investigation, duplicate sets of tensile and impact specimens were held at temperature in a protective atmosphere of helium for 20 days, one at 500 F (260 C) and one at 700 F (371 C).

Test Procedure

All tensile specimens, both irradiated and unirradiated, were pulled at room temperature in a horizontal, screw-loaded, electrically operated tensile tester. The specimens were pulled at a strain rate of 0.005 in. per min to an elongation of approximately 1 per cent. A load-elongation curve was autographically plotted using a microformer extensometer having a 1000:1 magnification. The specimen was then unloaded, a 20:1-magnification microformer extensometer substituted for the high-magnification instrument, and the specimen pulled to fracture. Measurements were made of length and minimum diameter before and after the test for determination of elongation and reduction of area.

Impact specimens were tested in a standard Sonntag impact machine. For testing at temperatures other than room temperature, the specimens were placed in a bath at the desired temperature for at least 5 minutes, then quickly (less than 5 seconds) placed in the machine and tested. The cooling bath used for tests below room temperature consisted of alcohol and dry ice, and heated water was used for all tests above room temperature.

Tests on all irradiated specimens were conducted without shielding or with temporary shielding only since the specimen activity was low (approximately 400 mr gamma and 500 mrep beta per specimen at 12 in.).

Results and Discussion

The results of the tensile tests are listed in Table 2,

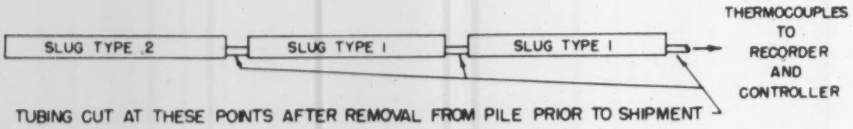

SLUG TYPE 2
SLUG TYPE 1
SLUG TYPE 1
THERMOCOUPLES TO RECORDER AND CONTROLLER
TUBING CUT AT THESE POINTS AFTER REMOVAL FROM PILE PRIOR TO SHIPMENT

Fig. 5 Pressure vessel steel irradiation slug assembly composed of two Type-1 and one Type-2 slugs connected to each other by $^1/_2$-in-diam aluminum tubing

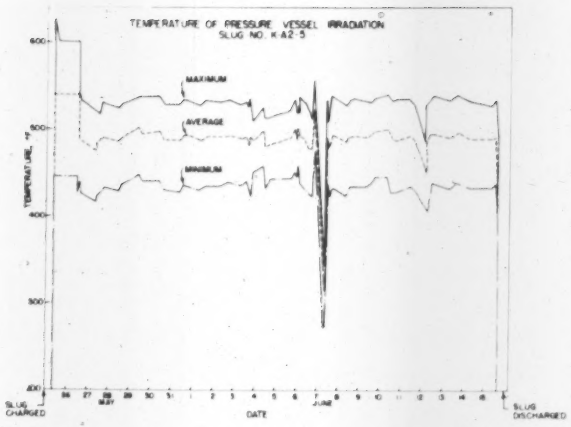


Fig. 6 Temperature of pressure vessel irradiation, slug number K-A2-5

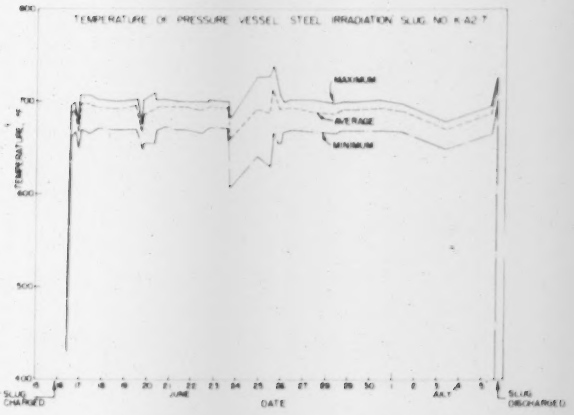


Fig. 7 Temperature of pressure-vessel irradiation, slug number K-A2-7

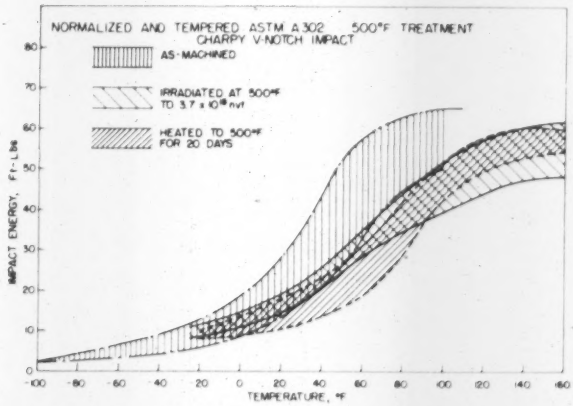


Fig. 8 Charpy V-notch impact on normalized and tempered ASTM-A302 with 500 F treatment

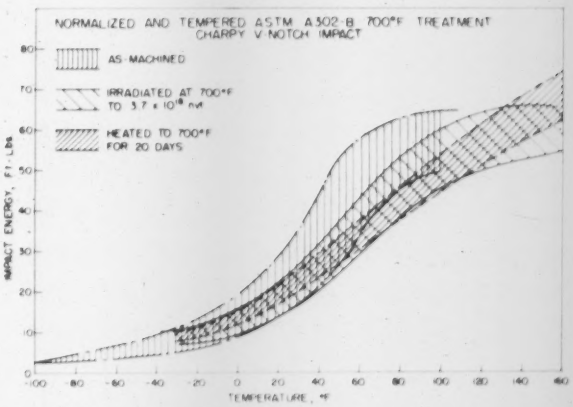


Fig. 9 Charpy V-notch impact on normalized and tempered ASTM-AsO2 B with 700 F treatment

and the impact-test results are illustrated in Figs. 8 and 9.

Examination of the data listed in Table 2 shows that for both the irradiation and thermal treatment, the tensile strength and ductility were changed. The magnitude of the changes expressed as a percentage of the original value are contained in Table 3. Also included are similar percentage changes in tensile properties of irradiated A212 B steel reported in the literature.[1]

Comparison of the values listed in Table 3 shows that the tensile properties of steel under investigation were changed both by thermal aging and by irradiation at the same aging temperatures.

Several generalizations can be made from these data. Holding at an elevated temperature for long periods of time results in a decrease in tensile and yield strengths, an increase in elongation, and a decrease in reduction of area. When the samples are subjected to neutron irradiation while kept for the same length of time at the same temperature, the change in tensile and yield strengths and in elongation is of the opposite sense, and the change in reduction of area is of the same sense but of greater magnitude than the changes produced by long-time heating without irradiation.

Table 2 Results of Tensile Tests[a]

	Ultimate tensile strength, psi	0.2 Per cent offset-yield strength, psi	Elongation, per cent	Reduction of area, per cent	Change in hardness, RA
Unirradiated control specimens	91,200	66,400	25.7	62.5	
Held at 500 F for 20 days	91,500	65,000	26.1	60.7	Not measured
Held at 700 F for 20 days	89,800	64,200	26.8	61.1	Not measured
Irradiated at 500 F to 3.7×10^{18} nvt	95,300	72,100	24.3	59.6	+0.3
Irradiated at 700 F to 3.1×10^{18} nvt	92,600	67,500	25.5	60.6	+0.5

[a] Average of four specimens tested in each condition.

[1] "Effect of Neutron Irradiation in Steel," by J. C. Wilson and R. C. Berggren, paper presented at ASTM annual meeting, June 26, 1955.

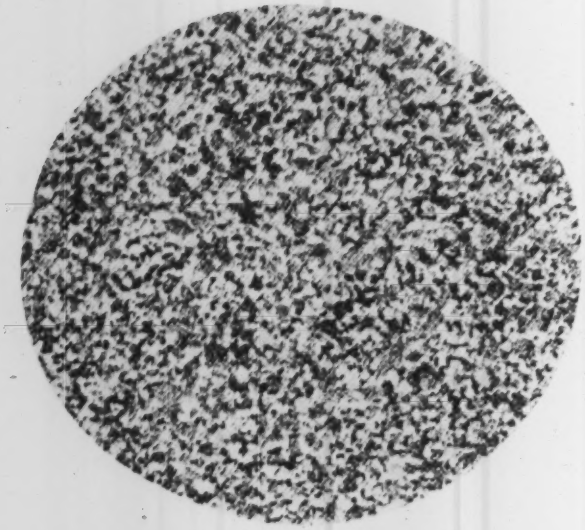


Fig. 10 Microstructure in the as-machined condition when normalized at 1650 to 1700 F and tempered at 1250 F. Sectioned transverse to rolling direction; ×100.

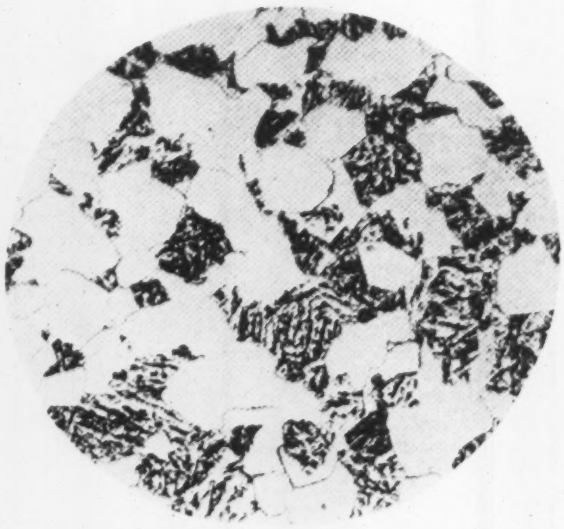


Fig. 11 Microstructure in the as-machined condition, when normalized at 1650 to 1700 F and tempered at 1250 F. Sectioned transverse to final rolling direction; ×750.

Table 3 Changes in Tensile Properties of Carbon Steel When Subjected to Thermal Aging and Neutron Irradiation[a]

Percentage change with respect to properties of unirradiated material

Steel	Treatment	Tensile strength	0.2 Per cent offset-yield strength	Elongation	Reduction of area
A302 B	Held at 500 F for 20 days	+3.3	−2.1	+1.5	−2.9
A302 B	Irradiated at 500 F to 3.7×10^{18} nvt	+4.5	+8.6	−5.4	−4.6
A302 B	Held at 700 F for 20 days	−1.5	−3.3	+4.3	−2.2
A302 B	Irradiated at 700 F to 3.7×10^{18} nvt[b]	+1.5	+1.7	−0.8	−3.0
A212 B	Irradiated at 120 F to 1×10^{19} nvt	+7.2	+30.6	−1.8	+6.7
A212 B	Calculated change if irradiated to 3.7×10^{18} nvt at less than 200 F	+2.7	+11.3	−0.7	−1.7

[a] Op. cit.
[b] See footnote 1.

Comparing the magnitude of the changes in tensile properties produced by holding at the two elevated temperatures for long periods, it will be seen that the higher temperature produces the greater annealing or softening effect. In other words, the higher temperature produces a greater reduction in strength and increase in ductility than the lower temperature, and when the material under investigation is irradiated at elevated temperature, the higher temperature is a greater deterrent to the embrittling effects of irradiation.

The integrated neutron flux to which the specimens in this investigation were irradiated is approximately one third of the irradiation to which the A212 specimens, whose property changes are compared in Table 3, were subjected. If it is assumed that (*a*) the behavior of the A302 steel under irradiation is the same as that of the A212 steel, (*b*) the change in impact and tensile properties is directly proportional to the integrated flux in the range of 1×10^{18} to 1×10^{19} nvt. and (*c*) the tensile reduction of area decreases uniformly with increasing amounts of integrated flux, then one can calculate the change in properties that the A212 specimens would undergo when irradiated to an integrated neutron flux of 3.7×10^{18} nvt. These calculated changes are listed in Table 3. When compared with similar values for the A302 steel it can be seen that irradiation at elevated temperatures does have a definite annealing effect upon the radiation damage of the A302 steel.

The Charpy V-notch impact behavior of the normalized and tempered specimens and in the as-machined, heated, and irradiated conditions is shown in Figs. 8 and 9. There was a considerable spread in the data of the as-machined specimens, but if the true-impact curve lies in the center of the scatter band, the 20-ft-lb impact transition temperature is approximately +22 F. The transition temperatures for all other specimen treatments are listed in Table 4.

Table 4 Charpy V-Notch Impact Transition Temperature

Specimen treatment	20 ft-lb transition temp, F
As-machined, normalized, and tempered	+22
20 days at 500 F	+46
Irradiated at 500 F	+32
20 days at 700 F	+22
Irradiated at 700 F	+32

The data in Table 4 indicate that the changes in transition temperature induced by radiation or thermal treatments were small (less than 25 F). The greatest change in transition temperature was exhibited by those specimens which were heated to 500 F for 20 days, but it is felt that this is only coincidence. In examining

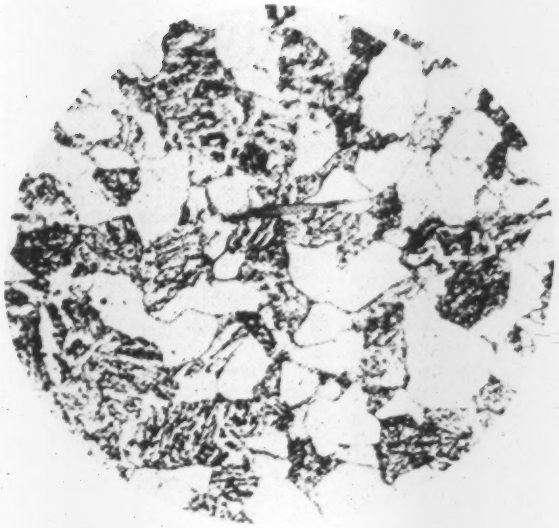


Fig. 12 Microstructure in the as-machined condition, when normalized at 1650 to 1700 F and tempered at 1250 F, and held 20 days at 500 F. Same sectioning, ×750.

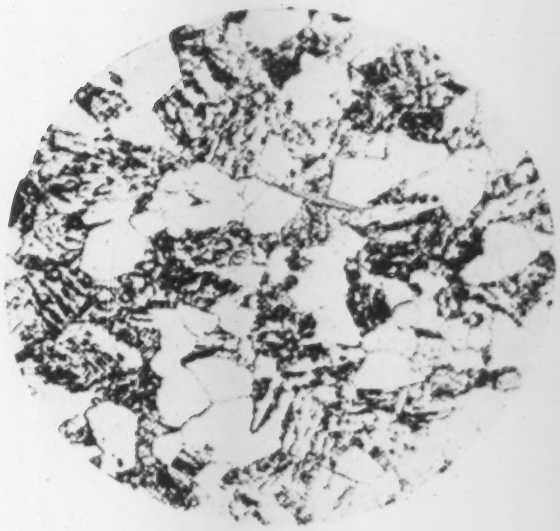


Fig. 13 Microstructure in the as-machined condition, when normalized at 1650 to 1700 F and tempered at 1250 F, and held 20 days at 700 F. Same sectioning, ×750.

the impact-energy versus temperature curves in Figs. 8 and 9, it appears that neither the irradiation nor the temperature has any significant effect on the 20 ft-lb transition temperature.

Regarding the effect of radiation on the Charpy V-notch impact strength of A302 B steel, it can be concluded that, under the conditions of this experiment, irradiation has little or no effect. There does seem to be a trend toward higher impact-energy transition temperatures with irradiation, and the effects would probably be more pronounced with greater amounts of radiation.

In summarizing, the changes in mechanical properties of normalized and tempered A302 B steel, induced by the conditions of this investigation, namely, neutron irradiation to a calculated integrated flux of 3.7×10^{18} nvt (fast) at temperatures of 500 and 700 F, consisted of slight increases in tensile and 0.2 per cent offset-yield strengths and in Charpy V-notch transition temperature, and slight decrease in per cent elongation and reduction of area. The embrittlement induced by the radiation was of a small magnitude, and it was felt that the damage was lessened by irradiation at elevated temperatures.

Comparison of the results obtained in this investigation with results published in the literature also indicates that there is a similar trend in the effects. With increased irradiation, it seems possible there will be increased damage, but the amount of damage will be inversely dependent upon the temperature; the higher the temperature, the smaller the amount of damage.

That the changes in properties are a result of radiation rather than microscopic changes induced by high-temperature aging is further evidenced by the microstructures exhibited in Figs. 10 to 13. The transverse structure of the material in the as-machined condition at a magnification of ×100 is shown in Fig. 10. The same structure at a magnification of ×750 is shown in Fig. 11. When comparisons are made, Figs. 11, 12, a transverse microphoto at ×750 of a specimen held at 500 F for 20 days, and Fig. 13, a transverse microphoto at ×750 of a specimen held at 700 F for 20 days, no difference in microstructure between the three samples can be seen. Since no detectable microstructural changes were caused by holding at temperature, then the minor differences in properties exhibited by the unirradiated specimens must be accounted for by submicroscopic changes in the material.

Conclusions

The following conclusions can be drawn:

1 When irradiated to a calculated integrated thermal neutron flux of 3.7×10^{18} nvt at temperatures of 500 and 700 F, there are only minor changes (less than 10 per cent) in tensile and yield strengths, ductility, and impact transition temperature of ASTM-A302 B steel.

2 Test results on irradiated and unirradiated specimens indicate that operation at elevated temperature results in some annealing of the embrittling effects of irradiation in agreement with published data on other steels.

3 Comparison of the results of the specimens irradiated as part of this investigation with data on the same properties for similar materials subjected to larger amounts of radiation (1×10^{19} nvt fast) indicates that an increase in the property changes can be expected for larger amounts of radiation than studied.

Acknowledgment

The author wishes to express his appreciation for the co-operation received from M. Fox, R. W. Powell, and J. J. Floyd of Brookhaven National Laboratory.

The author also wishes to acknowledge the aid of L. F. Coffin, Jr., R. F. Koenig, W. L. Fleischmann, W. E. Cooper, C. A. Bruch, M. Ciancetta, F. W. Wiesinger, and D. J. Ruggiero of the Knolls Atomic Power Laboratory in this investigation.

An Atomic-Powered Locomotive?

By Bruce C. Gunnell, Mem. ASME

Bush Hill Development Corporation, Alexandria, Va.

The study of the use of nuclear energy as a fuel to furnish power for railroad locomotives, suggested as early as 1946, is being carried on by many different engineering groups in an effort to determine the over-all economic facts of this type of fuel. At present it is questionable whether a nuclear-powered locomotive can justify its existence on American commercial railroads, but it does appear that such a locomotive has a place in our military service as well as in certain foreign countries where present-day type fuels are in short supply.

THE American Railroads are interested in atomic energy to furnish the power to haul our trains at a lower over-all cost than is being done by our present equipment.

Two Ways of Using Atomic Power

This may be accomplished by using atomic power in one of two ways, indirect or direct. If the indirect is used, the atomic energy would be converted into electric power at stationary plants and transmitted through overhead lines to conventional locomotives.

The use of atomic energy in a direct method on a railroad locomotive would mean that the atomic fuel would be carried in the locomotive and converted into power on this unit.

A locomotive in general terms is an engine which converts fuel or electric power into tractive effort at the rails, in order to exert drawbar pull on a train of cars, thus forcing these to move along the rails.

The main functions of such a locomotive are to convert fuel into heat, then change this heat into pressure, next, turn this pressure into horsepower through an internal-combustion engine, a steam engine, a steam turbine, or a gas turbine. This power is either carried directly to the rails through links or gears or is converted into electric power and then transmitted through cables and motors to the wheels. This is a rather simplified description, but it will serve the purpose in describing an atomic-powered locomotive.

When nuclear fission takes place, the kinetic energy, due to the velocity of the newly formed atoms and neutrons, causes them to move at such high speeds that they collide with other atoms, and the collision results in turning kinetic energy into heat. It is this heat that we plan to convert into power for use in our atomic locomotive.

Contributed by the Railroad Division and presented at the Annual Meeting, New York, N. Y., Nov. 25–30, 1956, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Condensed from ASME Paper No. 56—A-79.

Converting the Gas-Turbine Electric Plant

If we take a gas-turbine electric locomotive adapted to use atomic energy in place of conventional fuel, then the main factor is the replacement of the combustion chamber, fuel storage, and handling equipment with an atomic reactor.

The reactor may be a solid-fuel or a liquid-fuel type. It also may use a direct air-cooled cycle or an indirect liquid-cooled cycle.

In selecting the size and weight for an atomic locomotive we should start with one that can be used in freight and passenger road service and in switching service, on most of our standard American railroads, and also could be used by our military. It should be designed so it can be operated as a single unit or as multiple units from one control cab. The controls should be simple and maintenance cost reduced to a minimum. It should be designed so there is little potential danger to personnel or property.

Comparison With Diesel Locomotive

A diesel locomotive uses about 2 gal of fuel per 1500 hp per mile in road service. The over-all efficiency of this diesel will be about 28 per cent, at full throttle, full load, and this efficiency drops only slightly as the throttle and load are reduced.

A present-day oil-fired gas turbine will have about 15 to 18 per cent over-all efficiency at full throttle, full load. This efficiency falls very rapidly as the throttle and load are reduced due to the characteristics of the turbine design and also due to the large compressed-air requirement of the gas-fired turbine in order to control the temperature.

There are no efficiency data available on an atomic-energy gas turbine, but let us estimate the turbine as 20 per cent efficient, and the electrical transmission as 80 per cent efficient giving a total efficiency of 16 per cent.

From these figures we can list the following data in an effort to compare an atomic-powered gas-turbine electric locomotive with a modern diesel-electric locomotive as shown in Table 1.

We should now weigh the good and bad points of these two types of locomotives and, where possible, relate these comparisons in terms of money.

Fuel is our first item to consider. The purchase price of fuel on a large fully dieselized railroad operating about 1000 diesel units of 1500 hp each will run about 160,000,000 gal at $0.10 per gal, or $16,000,000 per yr.

It would take 500 atomic units of 3000 hp each to "atomize" this railroad.

Development Cost and Maintenance

The development cost of the first atomic locomotive would probably be at least $20,000,000. The cost per 3000-hp unit, after mass-production manufacturing is

Table 1 Comparative Costs Between Atomic-Powered and Diesel Locomotives

Data	Diesel	Atomic
1 Locomotive efficiency, per cent	28	16
2 Average fuel per mile, lb	28 (4 gal)	0.000,245
3 Estimated total fuel capacity, lb.	14,000	33
4 Estimated locomotive miles per month	12,000	12,000
5 Locomotive-miles per yr (No. 4 × 12)	144,000	144,000
6 Estimated portion of total Btu's used per fueling, per cent	100	20
7 Pounds used per fueling (No. 3 × No. 6)	14,000	6.6
8 Total Btu per lb of fuel, based on data available	20,000	40,000,000,000
9 Total Btu per mile used (No. 2 × No. 8)	560,000	982,000
10 Work in Btu per mile (No. 1 × No. 9)	157,000	157,000
11 Total Btu per fueling (No. 7 × No. 8)	28,000,000	264,000,000,000
12 Years between fuel changes No. 11/(No. 9 × No. 5)	0.00347 (once a day)	1.87
13 Fuel cost new (based on Prof. Lyle Borst's paper at Atomic Industrial Forum meeting, March, 1954), per lb	$0.0142857	$9,090.90
14 Credit for poisoned fuel (est. 1/5 of cost new fuel) per lb		$1,818.18
15 Net cost fuel per lb	$0.0142857	$7,272.72
16 Net cost fuel per fueling (No. 3 × No. 15)		$240,000
17 Net cost fuel per yr (No. 16/No. 12)	$57,600	$128,000
18 Net cost fuel per mile (No. 17/No. 5)	$0.40	$0.89
19 Per cent fuel cost (from No. 18)	100	222
20 Fuel, lb per hp per hr (No. 2 × 40 mph/3000 hp)	0.38	0.000,000,326
21 Fuel, lb per hp per hr atomic plane (*Life* 2/7/55) (800 mph × 5 lb)/(14,000 miles × 475,000 hp × 18 efficiency per cent)		0.000,000,340

started, would probably be about $1,000,000 each for the first 500 locomotives. If the development cost is absorbed by the first 500 units, then they would cost $1,040,000 each, as against a two-diesel unit costing about $300,000. The expected life would be about 15 years for each type. Therefore an atomic unit would cost $1,040,000 divided by 15 or $69,333 per yr, and two-diesel units would cost $300,000 divided by 15 or $20,000 per yr.

The maintenance cost of a 3000-hp diesel locomotive is about $0.40 per mile, or 144,000 × $0.40 = $57,600 per yr. In light of the fact that many parts of an atomic locomotive will be radioactive, "hot," causing it to be unsafe for mechanics to make repairs on the locomotive, the assemblies will have to be removed and set aside to "cool off," which may take months or years, before repairs can be made. In some cases the parts may have to be "dumped," which would result in a complete loss. A conservative estimated figure for maintenance cost per mile will be twice that of a diesel, or $0.80 per mile, or $115,200 per yr per 3000-hp unit.

Used Atomic Fuel Problem

The storage and handling of used atomic fuel are very difficult and require specialized equipment and personnel but the quantity of the fuel and the frequency of refueling will be much less than that required for diesel operation. The costs of fuel handling should balance each other.

However, the possible additional cost is combined with that of the liability insurance and other costs. The cost of the train crews should be the same for both types of power. These are some of the main costs and are enough for our present needs, as shown in Table 2.

Table 2 Comparative Operating Cost per Year of Diesel and Atomic-Powered Locomotives

Data	Diesel	Atomic
1 Expected life, yr	15	15
2 First cost @ 15-yr life	$20,000	$69,333
3 Maintenance per yr (diesel 40¢ per mile)	$57,600	$115,200
4 Cost of fuel per yr (No. 17, Table 1)	$57,600	$128,000
5 Cost of fuel storage, handling and liability in addition to diesel (est.)		525,000
6 Train crews same as diesel		
7 Extra cost supervision and training over diesel (est.)		$10,000
8 Total cost per yr per locomotive	$135,200	$347,233
9 Operating cost per mile	$0.94	$2.40
10 Per cent operating cost	100	255

NOTE: Interest on above fixed charges not considered.

Safety and Liability

We now come to the subject to which no one living knows the answer—safety and liability.

This can be broken down into two phases. One phase is the normal danger that personnel are subjected to the radioactivity of the atomic fuel. This, of course, will cost a great deal more than it does to train and supervise diesel maintainers, say, $10,000 per year per atomic locomotive.

The other phase is: What will be the consequence when something goes wrong with the equipment as a result of the failure of mechanical parts or personnel failure? There is not much danger from a controlled chain reaction resulting in an atomic explosion; in fact, this possibility can be disregarded. However, there is danger of the failure of some safety equipment which would stop the control rods from operating. The reactor in this case could get so hot that it might melt down and run out on the ground. Of course, if this happened, the ground would become so radioactive that personnel could not come near it. The track would have to be abandoned for a long period of time, or the ground dug up and carried away by the use of very special equipment. This would be particularly likely as the aftermath of a head-on collision.

Lawsuits to cover personnel and property damages would soon be under way—possibly even resulting in bankruptcy.

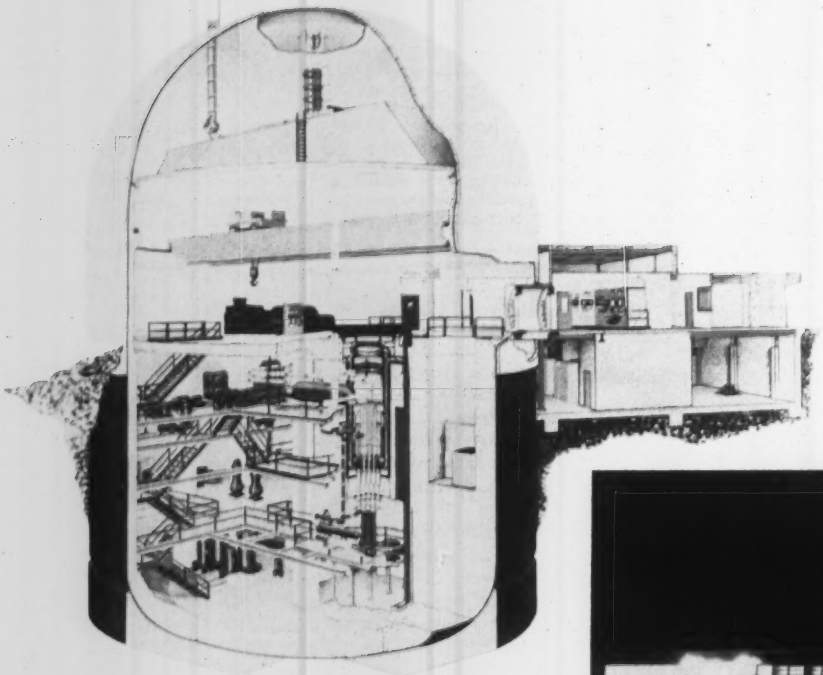
For Military Service

An atomic-powered locomotive cannot be justified for use on our American Railroad System for serving the public at the present time, or any time in the next ten years, but an atomic locomotive would prove very valuable at the present time in the military service. A 3000-hp unit may be a little large, but this can probably be reduced without too much difficulty. Think what a wonderful advantage it would be to have a military locomotive operating in some remote field that only required refueling every six months.

Briefing the Record

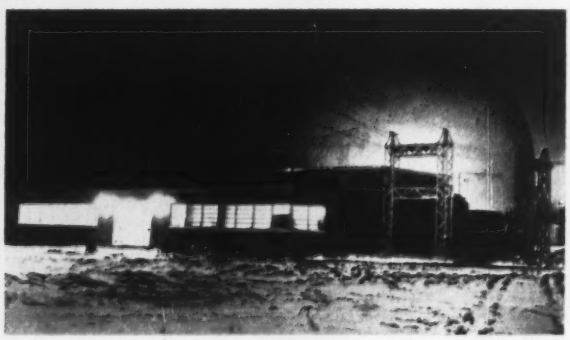
Abstracts and Comments Based on Current Periodicals and Events

J. J. Jaklitsch, Jr., *Editor*



Left: Cutaway perspective of entire Experimental Boiling Water Reactor Plan. The reactor is the structure nearly centered under the dome which extends through several levels.

Below: The exterior of the Experimental Boiling Water Reactor Building at the Argonne National Laboratory, Ill.



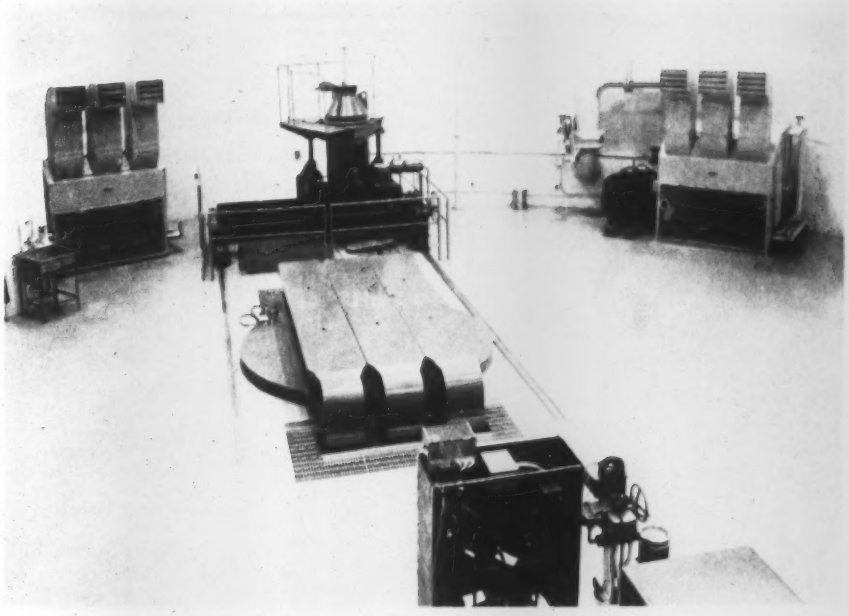
5000-Kw Nuclear Power Plant

The Experimental Boiling Water Reactor (EBWR) was dedicated at the Argonne National Laboratory, operated for the Atomic Energy Commission by the University of Chicago at Lemont, Ill., on Feb. 9, 1957. The $5-million 5000-electrical-kw nuclear plant is the first designed and built for the production of electrical power to come into operation in this country, in what AEC Chairman Lewis L. Strauss, speaking at the ceremonies, said may be "the year of the coming of age of nuclear power," since several other reactors will soon begin operation.

The EBWR incorporates a number of features which literally make this 488-F 600-psig light-water-moderated plant several reactors in one. It can accommodate a variety of core arrangements for experiments with both natural and forced circulation, and can be modified to operate with heavy water and a variety of fuel elements.

A number of pilot-plant and component studies will be made on the boiling-water-reactor concept, an efficient system which sends steam directly to the turbine-generator without intermediate heat exchangers, and which is also inherently the safest of the reactor types. Test runs which have been taking place since December indicate that the radioactivity carried to the turbine is much less than anticipated. Since the radioactivity is carried by the dispersed water particles in the steam, and the steam is nearly dry by the time it leaves the top of the reactor, what little radioactivity is left is removed in the drier before the steam reaches the turbine.

Several basic modifications of reactor vessel and containment building design are incorporated into the EBWR. Although the reactor should be able to operate at a power level at least four times its rating of 20 heat megawatts, and numerous safety precautions are incorporated, an additional safety factor is the use of three large strap beams to hold down the reactor-vessel plug in the event of an explosion. These beams are anchored 60 ft below in the concrete base of the containment building, and are protected against shearing by laminated mats of wood and steel. The beams and plug



The multiple steel beams in the center of the floor at the Experimental Boiling Water Reactor guarantee protection against an upward explosion of the reactor. The fuel-handling equipment can be seen behind the beams. A huge lead coffin is used to transfer fuel elements to a water-filled storage pit when not in use, as a protection against the intense radioactivity.

would confine the blast below the main floor where thick concrete shielding could absorb any fragments. No missiles would penetrate the steel dome or convert it into shrapnel.

Since the EBWR will be modified frequently for the various experiments, the control-rod-actuating machinery has been located beneath the reactor vessel rather than in the customary position on top. The top is a simple lid plug which can be removed easily for core or fuel-element modification. Fuel-element assemblies are inserted accurately and easily by the use of a positioning plate of two circular eccentric gears which can be set by the use of a chart and two sets of circumferential markings. The circular plate with its guide opening is quickly lifted into place by overhead crane.

The nine individually operated control rods pass through the base of the vessel where sealing is simpler since water is present rather than steam, as at the top. The rods extend through the entire core and are accommodated in the up position in the space between the top of the core and the top of the reactor vessel. Two types of control rods are used. Hafnium is the absorbing material in five of the rods which are located in the most effective (central) positions. The other four rods are made from stainless steel containing 2 per cent boron. Spring-accelerated gravity drop is preserved just as it would be if the mechanism were on top of the reactor, and deceleration is accomplished with dashpots.

The EBWR is a thermal reactor using enriched uranium fuel and moderated by naturally circulating ordinary water. The present roughly 4-ft-diam core consists of 114 fuel assemblies, of which 106 contain 1.44 per cent U-235-enriched uranium and 8 natural uranium. A 5-ft-diam core which will hold up to 148 assemblies can be used. Each fuel assembly is $77^{5}/_{8}$ in. long by $3^{3}/_{4}$ in. sq with six parallel uranium-zirconium-niobium-alloy sheets arranged with water-channel space between. Water enters the 7-ft-ID 23-ft-high pressure vessel at the base, circulates upward between the fuel elements, boiling, and becoming steam which passes out of the top of the vessel to the turbine-generator. The space between the core and the vessel wall serves as downcomer for the water as it circulates. The pressure vessel was built by The Babcock & Wilcox Company in accordance with the ASME Boiler and Pressure Vessel Code.

Steam in excess of that demanded by the turbine in response to generator load is by-passed through a desuperheater directly to a condenser. The new supercritical steam plants require a somewhat similar system to by-pass steam during boiler start-up.

The turbine-generator built by Allis-Chalmers is a conventional one, although new methods of pressure control, remote control, start-up, and shutdown had to be developed. The turbine is a multistage (1 Curtis, 11 Rateau) impulse unit rated at 3600 rpm, inlet 560 psig, 482 F at throttle, exhaust $2^{1}/_{2}$ in. abs, flow 62,700 lb per hr steam at full output. It is solidly coupled to the generator and direct-connected exciter. The generator is rated 5000 kw, 3 phase, 60 cycle, 4160 volts, 6250 kva at 0.8 pf, 0.8 short-circuit ratio; exciter ratings are 25 kw and 120 volt d-c. This air-cooled unit with air-to-water heat exchangers is similar in size and rating to many units built for industrial and municipal power plants, and the output is used to fill part of the power requirements of the Argonne National Laboratory.

The condenser, which includes many departures from standard design because of the extreme leak-tightness requirement and need for avoidance of any reactor feedwater contamination, is of divided water-box design permitting half shutdown in case of a tube rupture. It is rated 5300 sq ft, with 68,700 lb per hr steam load at 5000 kw, $2^{1}/_{2}$ in. abs vacuum, 13,650 gpm max. circulating water flow (85 F), 108.7 F condensate.

Sargent & Lundy were consulting engineers, the Sumner Sollitt Company was general contractor. Most instrumentation was by Leeds & Northrup Company.

Catalyzed Nuclear Reaction

A NEW phenomenon discovered in the University of California Radiation Laboratory, described as a "catalyzed nuclear reaction," has been announced by the Atomic Energy Commission, and adds a third way of making a nuclear reaction take place.

The older ways are the inducement of thermonuclear reactions, in which two light nuclei fuse into a heavier one when the temperature is raised to roughly one million degrees; or bombardment of nuclei with other nuclear particles from accelerators like cyclotrons or nuclear reactors.

In order to make a nuclear reaction take place, two nuclei must touch. The new discovery is a way of pulling two nuclei together so that a proton and a nucleus of heavy hydrogen (a deuteron) can combine to form helium-3 with the release of 5.4 million volts energy. This pulling together takes place in a "mesic molecule."

In a normal molecule the nuclei of the component atoms are pulled together weakly by electrons, but the electron can be replaced by a much heavier particle, the negative mu meson. Because the mu is 200 times heavier than an electron, it circles the nucleus at only 1/210th the distance of an electron, and thus binds the two nuclei correspondingly closer. The nuclei then have a good chance of touching, and the nuclear reaction can take place.

The reaction is termed a catalyzed reaction because the mu meson is not consumed but may be ejected from the molecule by the energy released. The mu is then free to catalyze more reactions, in chain fashion.

At the present time the energy-producing reaction is only a laboratory phenomenon since the chain of catalyzed reactions cannot continue long enough to generate commercially useful amounts of power.

Nuclear Briefs

Portable Nuclear Power Plants

SMALL, easily transportable, nuclear power plants may soon be generating electricity in remote mining areas and serving as atomic workhorses for scores of other industrial uses including marine propulsion and the production of process heat.

The Hawker Siddeley Nuclear Power Company, an English subsidiary of the Hawker Siddeley Group, Ltd., has begun work on a liquid-metal-fueled type of reactor which, it is hoped, can be applied to such uses.

Nuclear-Powered Merchant Ships

The Atomic Energy Commission and the Maritime Administration have announced a joint long-range program aimed at developing reactor systems for commercially competitive propulsive power for merchant ships. This program is in addition to the work now progressing on development and construction of the first nuclear-powered merchant ship, announced by the President on Oct. 15, 1956.

Under the joint program, the AEC is responsible for funding and directing the development of merchant-ship reactors. In general, the Maritime Administration is responsible for funding and directing the construction of ships, propulsion plants, and nuclear reactors which have passed beyond the development phase. The two agencies have contracts with private companies for six design-feasibility studies of four reactor systems.

Industrial Radiation Center

Radiation Applications, Inc., of Long Island City, N. Y., is the first privately owned industrial radiation center in the New York area. The company, organized in 1954, serves as consultant on specific radiation applications, surveys possible areas of utilization, and conducts experimental research and development programs for industry on both a service and contract basis.

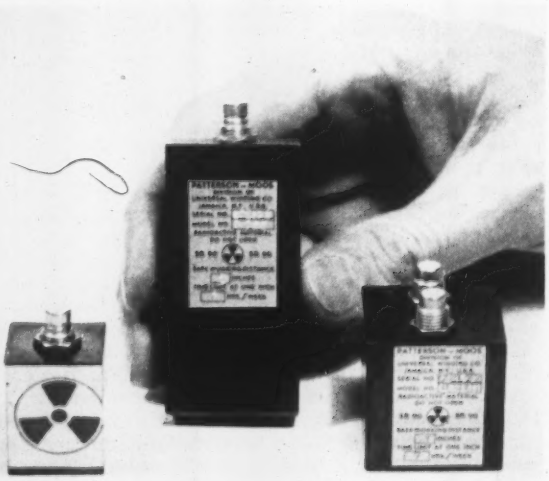
Equipment includes a 1350-curie cobalt-60 radiation source composed of four flat $2 \times 14 \times {}^{1}/_{16}$-in. plates, each weighing less than a pound, housed in a completely sealed 7500-lb mobile lead shield $26{}^{1}/_{2}$ in. in diam. Material to be exposed is placed in a 3-ft-deep pit, the lead shield moved over the opening, the source lowered into the pit, and the material thus irradiated.

Nuclear Power Packs

A family of small, light nuclear power packs ranging from less than 1 cu in. to 2 cu in., having a shelf and use life of over 25 years, energy pulses up to 337,000 ergs, and capable of operating over wide ranges of temperature, acceleration, and vibration, has been developed by Patterson Moos Division, Jamaica, N. Y., of Universal Winding Company. The nuclear power packs are suitable for use in weapon and ordnance systems as power sources for warheads, fuzes, destructers, timers, and programming devices.

Heart of the power pack is a nuclear battery which converts nuclear energy directly into electric energy. It is made with current ratings from 5 to 5000 micro-microamperes and equilibrium voltages in the order of 10,000 volts.

In the power packs the constant current characteristics



A family of small, light nuclear power packs ranging from 1 cu in. to 2 cu in. having a shelf and use life of over 25 years for use as power sources for warheads, fuzes, destructers, timers, and programming devices

of the nuclear battery are used to charge a capacitor making available a pulse source of electrical energy of essentially zero impedance. Pulse energy may be used repeatedly and means are provided to reliably regulate capacitor voltages at specific values between 75 and 750 volts.

Reactor Experience

The Preliminary Pile Assembly (PPA) of the Knolls Atomic Power Laboratory (KAPL), the first atomic reactor operated in the northeastern United States, has been started up and shut down a record 10,000 times for experimental purposes. PPA has functioned for $8^1/_2$ years and "is believed to have produced more information about a larger variety of reactors than any other assembly." It is one of five experimental reactors at the KAPL operated by General Electric for the AEC.

The prototype power plant for the submarine *Seawolf* and the actual *Seawolf* power plant were tested with the PPA, and the Submarine Advance Reactor for use in the world's largest submarine, the *Triton*, is now under construction.

Westinghouse Testing Reactor

The AEC has filed notice of the proposed issuance of a construction permit to the Westinghouse Electric Corporation authorizing construction of a testing reactor in Sewickley Township, Westmoreland County, about 29 miles southeast of Pittsburgh, Pa. The reactor will be cooled and moderated by ordinary water under pressure, and will use uranium enriched in the isotope U-235 as fuel. To be known as the Westinghouse Testing Reactor, the facility will generate heat equivalent to 20,000 kw. It will be used for developing and testing power-reactor fuel elements, for radiation-damage testing of materials and components, and for limited production of radioisotopes. Westinghouse plans to make the facility available to others on a commercial basis.

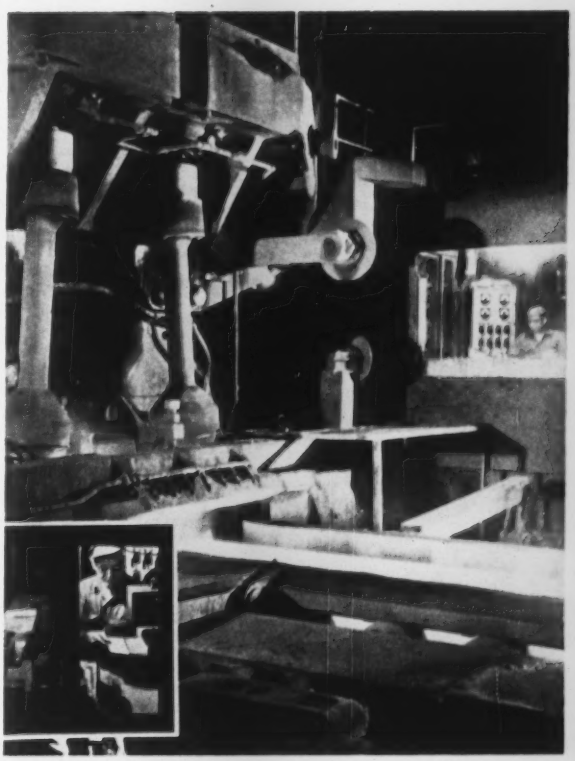
Plainsboro Research Reactor

The AEC has issued a permit to AMF Atomics, Inc., of New York, N. Y., a division of American Machine and Foundry Company, for construction of a "pool-type" research reactor in Plainsboro Township, N. J. The 300-acre site is in a farming area about $4^1/_2$ miles from Princeton, N. J. The reactor will operate at power levels up to 5000 kw to provide fast and thermal neutron fluxes and gamma rays for a variety of experimental applications. Ownership of the reactor eventually will be shared by a group of industrial concerns to be associated under the name Industrial Reactor Laboratories, Inc.

It will be similar to the Bulk Shield Test Facility which has been in operation at the Commission's Oak Ridge National Laboratory, Oak Ridge, Tenn., since early 1951.

Punch-Card-Controlled Steel Mill

WHAT is believed to be the world's first punch-card-controlled steel mill, which has certain controls and speeds automatically set, is now turning out tons of steel daily at the Brackenridge Works of Allegheny Ludlum Steel Corporation, Pittsburgh, Pa.



This punch-card-controlled steel mill, at the Brackenridge Works of Allegheny Ludlum Steel Corporation, is turning out tons of steel daily. The inset, *lower left*, shows the operator putting the punch card into a card reader. A button is pushed which sends electrical impulses to a master control, and the number of passes, the speed of rolling, and the sequence and amount of slab reduction are read from the card.

The same operator who manually operated the mill in the past uses the cards to help control the mill today.

The system uses punch cards on a 56-in. universal roughing mill with certain areas cut out. These holes indicate the number of passes, the speed of rolling, and the sequence and amount of slab reduction.

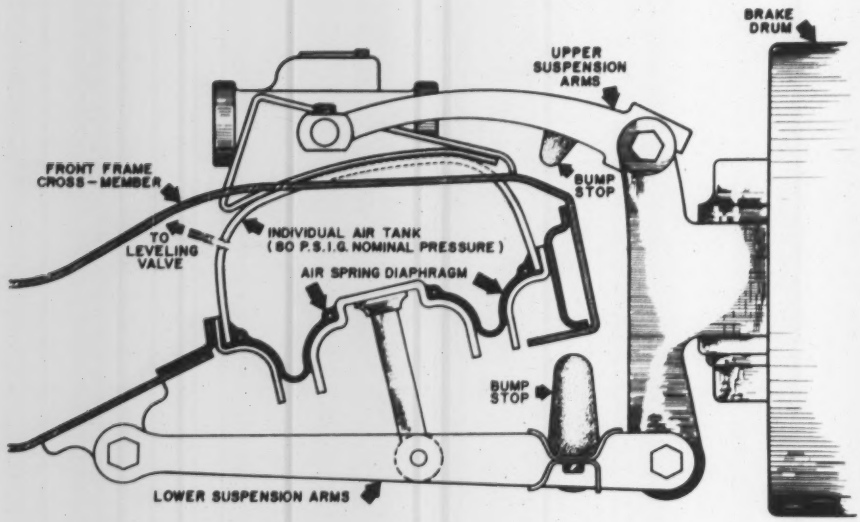
The control system was developed, manufactured, and installed by General Electric Company engineers.

The card system is designed to improve the quality of product and the output of the mill. By performing the rolling operation the same each time, as predetermined by rolling experts, there is greater control of the quality of the steel. The rolled material is always of uniform size, and the steel, from day to day, has better, more constant physical properties.

In working the card system the punched cards are inserted into a card reader, and a button is pushed sending electrical impulses to a master control which activates the mill.

The cards have as many as 15 programmed passes with accuracies of about $^1/_{100}$ in. There are six possible speeds which are predetermined and recorded on the card. The maximum opening of the mill is 9.99 in. with a top screwdown speed of 40 in. per min.

The use of punched cards permits the operator to maintain a large file of schedules for a wide variety of products.



Schematic drawing shows a typical front air suspension on a passenger car. Curved heavy black line is rubber and nylon-fabric diaphragm made by U. S. Rubber Company. As load conditions of the car change, diaphragm moves upward or is pushed downward. Air spring replaces conventional metal springs in the front suspension. Similar installation on rear axle replaces metal leaf springs. Tests show diaphragm will outlast the life of the car.

Air Springs

THE first air springs to be used on an American passenger car are being installed in the 1957 Cadillac Eldorado Brougham, according to United States Rubber Company.

The new springs will take the place of metal coil and leaf springs which have been standard in the automotive industry for many years.

"While air springs have been used on buses and truck trailers for some time, these are the first to be accepted for actual passenger car use," according to G. Raymond Cuthbertson, vice-president, and general manager of the rubber company's tire division. "We believe air springs will be in general use in the automotive industry by 1960."

He also announced first deliveries of a new tire engineered especially for the Brougham. Although it is a 15-in. tire, the U. S. Royal 140 lowers the height of the car more than a comparable present-day 14-in. tire would. It has been built to take the maximum speed of the car under continuous operation, he said.

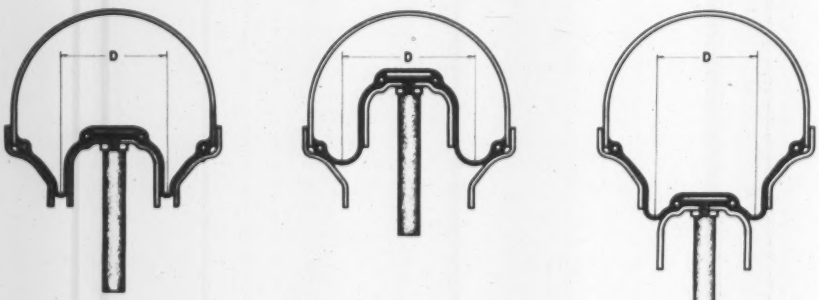
The air springs, Mr. Cuthbertson said, would enable auto stylists to drop the height of cars without reducing ground clearance.

"Designers today have to allow for the settling down that takes place when a car is fully loaded," he pointed out. "Consequently, when empty, the car rides high.

"Since the height of the body above the axles of a car equipped with air springs stays the same whether loaded to capacity with passengers and luggage or occupied only by the driver, the body can be set lower on the axles."

Designed to give a boulevard ride over almost any surface, the air spring transmits very little of the road shock from deep chuckholes or other road hazards. Smaller jolts are completely absorbed. The result is a ride described by engineers who have ridden air-spring test cars as the closest thing to flying.

Other advantages cited for the air spring were: The car stays level no matter how heavily the rear is loaded, giving the driver a better rear view; and front-to-rear pitching over big bumps is eliminated.



Operation of air spring developed by U. S. Rubber is shown by drawings. Heavy black line in each sketch is rubber and nylon-fabric diaphragm which is held in place by air pressure in the tank. As load conditions of the car change, diaphragm is pushed out or moved upward. In the actual installation, the lower end of the metal piston is attached to the lower arm of the auto suspension. The load on the car axle is balanced by air pressure on the top of the diaphragm. When the wheel strikes a bump the piston is forced upward, increasing the pressure in the chamber and the effective area on which the pressure is applied. The car body literally rides on air.

The air spring is actually a rubber and nylon-fabric diaphragm which is fitted onto the open end of a metal air tank and held in place by air pressure. One air spring is used at each wheel.

A metal piston for each diaphragm, self-regulating air valves, and an air compressor are included in the air-spring system. The diaphragms have been tested to millions of full-stroke cycles, and auto manufacturers say they will outlast conventional steel springs.

New Arc-Welding Process

A NEW process for welding mild steel, called Unionarc, has been developed by Linde Air Products Company, a Division of Union Carbide and Carbon Corporation.

Unionarc welding is a manual arc-welding process embodying a continuously fed wire electrode which is magnetically coated with flux and shielded in a gas atmosphere. This process is presently being used to produce high-quality welds in steel. It can be used in all positions at greater speeds and lower costs than covered electrodes.

In Unionarc welding, a bare wire electrode of common steel composition is continuously fed from a 300-lb-capacity pack through a flexible tube to the torch. The operator starts and continues welding to suit his requirements. There is no frequent stopping to change electrodes nor a series of starts and stops in making a joint. The wire is supplied in a "Pay-Off Pak," covered to keep the wire clean. The pack is supported and rotated on a motor-driven turntable, controlled so that wire tension at the feed rolls is minimized. The large wire pack provides at least one week's supply with average welding conditions.

Specially compounded and carefully produced magnetizable flux is placed in a dispenser and fed from this point through a flexible tube to the torch. The dispenser is designed to measure exactly the amount of flux in proportion to the amount of wire that is being fed. The dispenser can be adjusted to feed different flux-to-wire ratios, but the usual ratio is between $^3/_8$ to $^1/_2$ lb of flux per lb of wire. This predetermined ratio is automatically maintained regardless of the rate of wire feed.

The flux is fluidized at the dispenser in a stream of welding-grade carbon-dioxide gas. The gas, supplied from the usual commercial containers, is regulated as to pressure and flow and carries the flux to the torch suspended in the gas stream.

At the torch nozzle, the magnetic field created by the electric current passing through the wire, magnetizes and attracts the flux to the wire. As a result, the wire is "coated" as it is fed into the arc. The flux melts and does four important jobs: (1) Together with the shielding gas, it stabilizes the arc and the stream of molten metal passing through it to the puddle, and protects the puddle from atmospheric contamination; (2) it refines the molten metal by deoxidation; (3) it provides the desired control of weld contour by its effect on surface tension; and (4) it provides the desired cooling rate of the weld metal by its blanketing and insulating action.

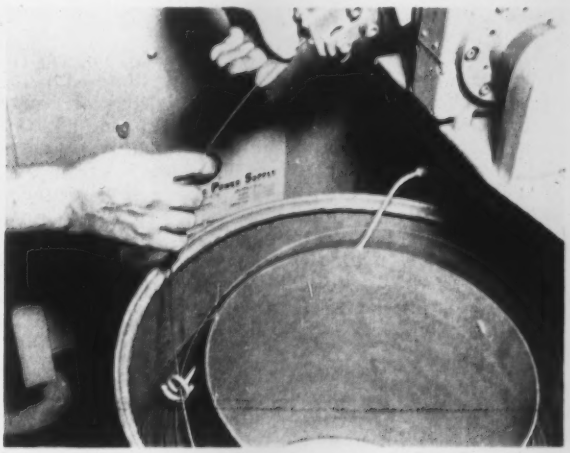
The welding current is supplied by a direct-current power source. A constant potential rectifier can be used with the added advantage of insuring easy and uniform starting and control of arc length.

The arc characteristics of Unionarc welding are similar to those of covered electrode welding. Under most welding conditions, metal transfer is "spray-type," and very little spatter is evolved.

The welding techniques used with Unionarc welding are comparable to those employed with the most commonly used covered electrodes.

The sequence of starting and stopping the flow of

Welding wire and flux issue simultaneously from the Unionarc welding torch nozzle as operator pushes the 2-way control switch on the torch handle. When welding current is flowing (not on in this picture), the flux is attracted to and coats the wire. Flux dispenser is shown at upper right. Manual skill and dexterity requirements are equivalent to, or are less than, those for covered electrode welding.



Although the wire is fed to the torch, and its feed rate controlled, by the assembly at the top of the picture, the much heavier load of rotating the wire pack is operated separately. As the wire feed rolls pull wire from the pack, it raises the actuating arm of the limit switch, through the end of which the wire passes. This energizes a separate motor that rotates the wire pack and loosens the top two or three loops of wire.

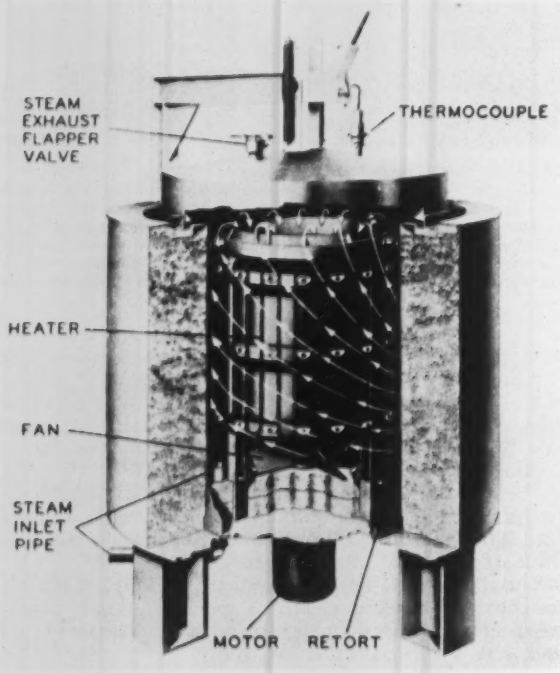
current, wire, flux, and gas, as well as maintaining proper welding conditions is regulated through an electronic control unit.

Unionarc welding deposits weld metal at a rate that is 50 to 100 per cent greater than that obtained with covered electrodes on the most common downhand welding applications. In the vertical and overhead positions the Unionarc deposition rate is 2 to 3 times as great as that of covered electrode welding. Moreover, since Unionarc welding utilizes a continuously fed electrode, the operator can devote more time to actual welding.

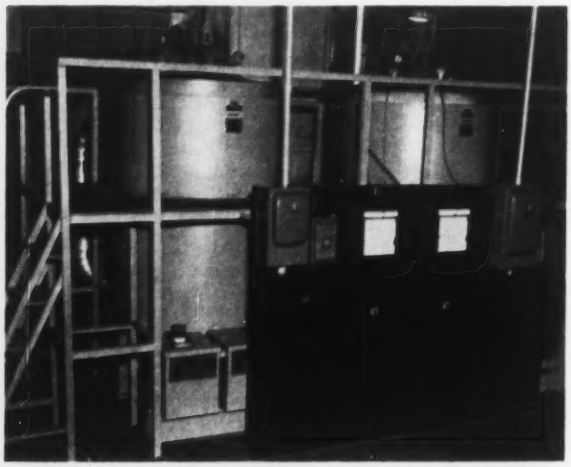
Unionarc welding is versatile. It can be used to weld across gaps and along seams containing moderate amounts of rust, scale, and moisture without effect on weld soundness. High desposition rates, along with high operating factors, materially reduce welding costs on many applications now being welded by other manual welding means.

Steam Atmosphere Heat-Treating

MANY metalworking plants are realizing substantial savings in tempering, annealing, and stress-relieving through the use of steam atmosphere heat-treating. In furnaces specifically designed for this method by Leeds & Northrup, both ferrous and nonferrous parts receive scale-free heat-treatment at temperatures up to 1250 F. Resultant work has such product advantages as superior wear resistance, longer life, better machinability, and greater corrosion resistance.



Cutaway view of Leeds & Northrup Company's "Steam Homo" furnace—a batch-type unit designed for steam-atmosphere treating by electric heat and forced-convection circulation at temperatures up to 1250 F



This twin-furnace installation includes both steam-treating and preheat units with separate temperature controls for mass-production bluing of rotors and stators for hermetically sealed motors. Parts must meet strict surface specifications for color and corrosion-resistance.

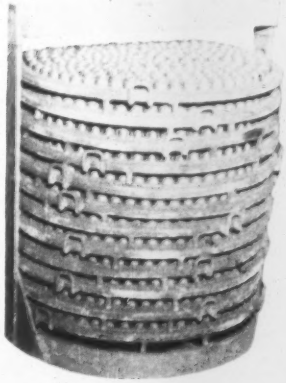
In addition to improved properties of the work, steam treating, it is claimed, can reduce or completely eliminate many time-consuming finishing operations. A series of typical applications which suggest how this type of heat-treatment can be of direct benefit to users are summarized in Table 1.

Plants often install the steam-treating furnace and accessory temperature controls directly in production lines.

After work is loaded, operation starts with bringing the furnace up to 650 to 750 F with air atmosphere. This

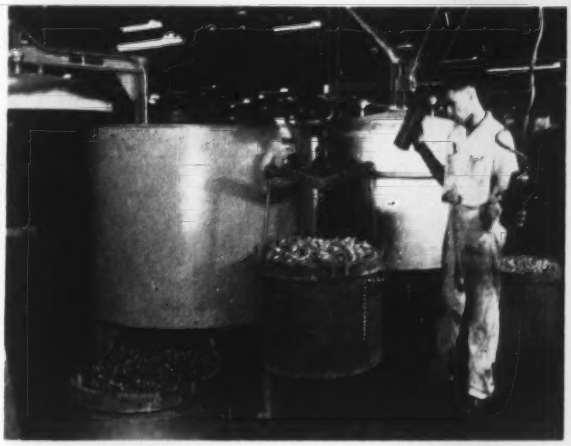
Table 1 Summary of Applications—Steam Atmosphere Heat-Treating

Product	Material	Process
Ferrous metals		
Cams, bearings, valve tappets, pistons, piston rings, etc.	Cast iron	Controlled oxide coating
Saw blades, machine parts	Steel	Controlled oxide coating
Twist drills, taps, reamers, counterbores, punches, etc.	High-speed steel	Controlled oxide coating
Rotors and stators for hermetically sealed electric motors	Laminated silicon steel	Controlled oxide coating
Postage-meter parts, sewing-machine parts, guns, toys	Steel	Bluing
Gears, bushings, pistons	Powdered metal	Controlled oxide coating
Nonferrous Metals		
Cosmetic cases, faucet spouts, radiator vent caps, 30-caliber shells	Brass	Annealing after progressive deep-drawing operations in fabrication
Valves, regulators, gas torch nozzles, fasteners, cosmetic containers, etc.	Brass or bronze	Stress relieving after machining
Clips, springs, electrical components	Beryllium copper	Precipitation hardening or aging
Instrument parts	Aluminum alloy	Solution treating



These powdered-iron shock-absorber pistons show increased hardness and compressive strength after steam treatment. Furnace in production line saves nearly three hours' handling time daily.

Here, cast die stocks, tap wrenches, and cutting tools are clean-tempered and stress-relieved in steam atmospheres. Process paid for itself through lowered bluing costs alone.



Steam atmosphere treating of these cast-iron automotive parts eliminated a chemical surface treatment formerly required for proper lubricating quality. Company also steam-treats its high-speed steel form tools; gets 50 to 75 per cent longer life before regrinding.

Steam-bluing of these postage-meter parts replaced cadmium-plating and resulted in closer-fitting, smoother working parts. It also reduced finishing costs.

preheats work and prevents condensation of steam on cold work. Automatic controls hold this preheat temperature for 30 min while injected steam purges air from the work chamber. The load is then heated to soak temperature and held automatically for the specified time, with steam flowing through the furnace.

At the end of the soak, work is either air-cooled or quenched in soluble oil. When handling nonferrous materials which require lower soak temperatures, the furnace may be purged at as low as 400 F, and parts are often quenched in water.

Cost of furnace atmosphere is low— a few cents per 100 lb of load, in most plants. For continuous production work, a commonly used furnace size requires about 50 lb of steam per hour. Steam can come either from a plant line or a small electric or gas-heated steam generator. The steam feeds through an inlet in the furnace bottom and exhausts through a flapper valve in the lid.

Electric heating is obtained by a continuous run of heavy-gage spiral wire surrounding the work space. A fan provides forced-convection and uniform rapid heating.

Automatic control of temperature in the work chamber is obtained by precise regulation of electric current to the heating element. A thermocouple, located directly in the work chamber, is connected to the panel-mounted Speedomax recorder-controller. This instrument provides a continuous quality-control record of the temperature and, at the same time, proportions heat input according to the load demand.

High-Temperature Alloy

A NEW high-temperature nickel alloy which is expected to find wide use in highly stressed parts of jet-engine combustion systems has been announced by The International Nickel Company, Inc. The new material, which will be marketed under the trademark Incoloy "T," may also find future application in airframe parts of planes to be used for hypersonic flight at speeds encountered in the region of the thermal barrier.

Incoloy "T" titanium-containing nickel-iron chromium alloy is produced as a strong sheet material designed to operate at temperatures up to 1400 F and, in

some applications, even higher. It is similar in composition to Incoloy nickel-iron chromium alloy and contains in addition about one per cent titanium.

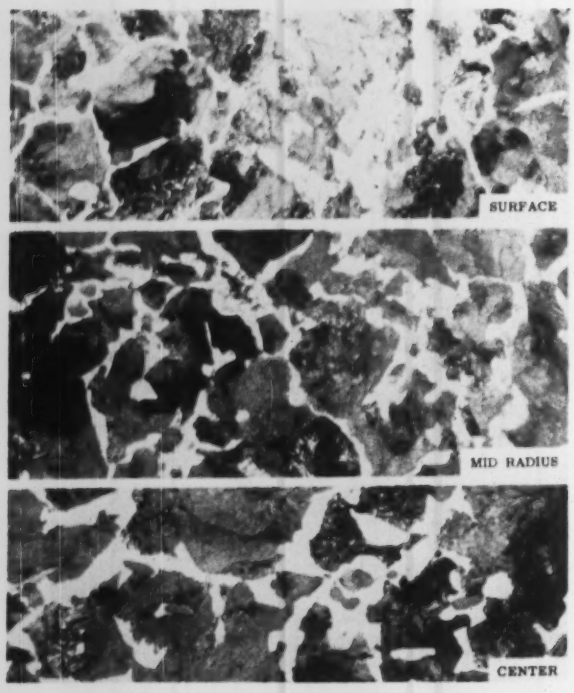
Incoloy "T" alloy has excellent oxidation resistance at temperatures up to 1600 F. Cyclic oxidation tests conducted on the alloy at 1600 F for periods from 100 to 1000 hr showed that the change in weight with time was of the same order for Incoloy "T" as for Incoloy. At 1600 F, for both of these materials, change in weight in cyclic oxidation is a gain because of the tight adherence of the oxide layer that is formed.

Incoloy "T" sheets as produced are annealed at 1900 to 1950 F. Fabricators using the alloy have obtained an excellent combination of formability and strength by process annealing components at 1800 F to 1850 F from 20 to 30 min, followed by rapid air cooling.

For properties at temperatures below 1200 F, the tensile and rupture strengths can be improved by cold-working. Since this alloy is usually fabricated into components where attachment by welding is necessary, cold-working for the purpose of increasing strength is not recommended.

Elevated Temperature Drawing

A NEW process for the production of materials with a unique combination of physical and mechanical properties has been announced by La Salle Steel Company of Hammond, Ind. This process has been named "e.t.d." (Elevated Temperature Drawing). The properties depend upon, first, careful selection of a particular material composition of steel; second, the control of the amount of deformation by reduction; third, the temperature at which deformation is carried out to bring about metallurgical changes which result in a new combination of physical and mechanical properties not heretofore available. This procedure has been developed to create a new combination of properties. It is not designed to facilitate the deformation process.



Photomicrograph of "Fatigue-Proof" structure shows a uniform pearlitic structure. Retained austenite and untempered martensite cannot be present. This remarkable uniformity is a result of manufacture by the new Elevated Temperature Drawing process.

For the first time in steel-bar products, the dimensional tolerances, surface finish, and excellent machinability generally associated with cold-finished bars have been incorporated into a bar product which also has strength properties normally developed by heat-treatment. (Heat-treatment here is meant to describe the standard quench and temper cycle for hardening steel.) Further, it eliminates the need for heat-treating and attendant operations in many instances for consumers.

Elevated Temperature Drawing involves the selection of bar chemistry, the amount of reduction in cross-sectional area of the bar as it is drawn through a die, and a drawing temperature which will result in the desired final properties.

These properties occur as a result of three metallurgical phenomena which take place in the bar as it is deformed at elevated temperatures (between 200 F and below the lower critical temperature).

First, the steel bar strain-hardens by appropriate slip processes within the crystal structure. Second, it age-hardens by precipitation of nitrides along with precipitation of carbon from supersaturated solid solutions. Third, a substructure within the grains develops as a result of the deformation at elevated temperatures.

Proper control of these metallurgical processes results in the unique combination of properties which can be produced by e.t.d.

On Sept. 6, 1955, "Fatigue-Proof," a new material embodying a new combination of properties made by this process, was made available commercially.

For the first time, a steel-bar product is offered commercially which has guaranteed Rockwell C values of 30, a tensile strength of 140,000 psi, and a yield strength of 125,000 psi. In addition, the material has remarkable free machining characteristics. It machines about 25 per cent faster than annealed alloy steel and as much as 100 per cent faster than alloy steel heat-treated to the same strength level.

Inherent in the manufacturing procedure is a uniformity of property from heat to heat, bar to bar, and across the diameter of the bar which has heretofore not been available in quenched and tempered bar stock.

The product was named Fatigue-Proof to bring to the attention of designers and other interested materials users its improved life in service. Actual fatigue tests support this fact.

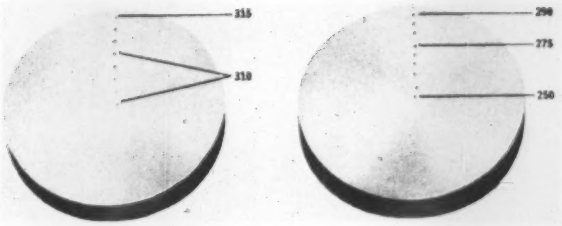
This first new product of the Elevated Temperature Drawing process illustrates the versatility of this new process.

To summarize, the e.t.d. process holds promise of bringing about the following:

1 The lessening of the dependence on strategically scarce alloys.

2 The making possible of combinations of properties not economically attainable by present methods.

3 In many cases the elimination of heat-treatment and subsequent operations.



Comparative transverse hardness—Fatigue-Proof's hardness as produced by the e.t.d. process is consistent and uniform. The example at *left* is $1^7/_8$-in. round Fatigue-Proof and shows a range of 315 to 310 Brinell only. The $1^7/_8$-in. round 4140 (quenched and tempered) at the *right* varies from 290 at the surface to 250 at the center. These are typical.

4 The combination of high strength with improved machinability.

5 The direct production by machining operations only of parts which have previously required multiple and often costly operations.

Optical Tooling

In most cases, engineering products are developed at the specific request of the industry or industries that first realize a need for the products. Less frequently, a manufacturer or supplier of engineering equipment will develop a new product or technique independently, relying on his own engineering ability and experience to promote acceptance of "the better method."

Such was the case with Brunson Instrument Company, Kansas City, Mo., which developed two new highly successful techniques in the field of optical tooling: (1) The Brunson optical-grid co-ordinate method of measurement; and (2) the Brunson cross-wire projection method of locating points.

Both these techniques now enjoy wide acceptance in industry and are serving in a variety of applications, including aircraft inspection, guided-missile assembly, measurement of radar screens, checking of large assembly jigs, inspection of large machine tools, and quality-control inspection of critical component parts.

Co-ordinate systems of measurement have been used for years. Perhaps the best-known application is in connection with the use of ordinary graph paper or "data" sheets, where points can be located and distances accurately measured with or without the use of a scale. Another example of a grid system is in navigation, where the earth is divided conveniently into longitudes and latitudes for ease of accurate measurement and positioning.

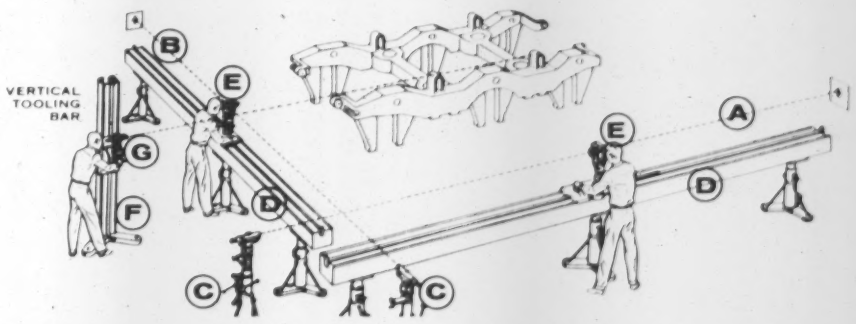
The Brunson optical-grid method of measurement utilizes the same principles to provide industry with a micrometer-accurate system of measuring, aligning, inspecting, and positioning large or small objects and for locating points.

In the basic Brunson grid system shown in the illustration, two reference lines of sight (A and B) are established at right angles to each other. The two lines of sight are maintained by two alignment telescopes (C). Two horizontal "tooling bars" (D) are placed along the lines of sight. These bars provide a "track" on which the key instruments in the setup—the optical transit squares (E) can be moved and positioned. Directed at the object being worked on, the telescopes on the transit squares provide lines of sight which are at precise right angles to the reference lines of sight A and B. The telescopes can be elevated or depressed as required to line up with given points or to "sweep" vertical planes.

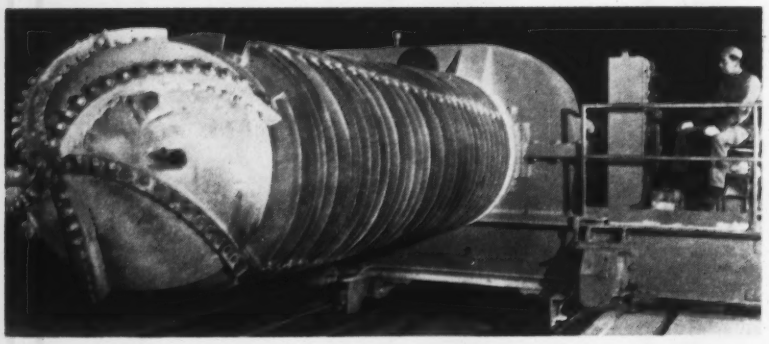
Thus, an invisible but real three-dimensional grid system is established around and against the object being worked on. The ability of the optical transit squares to sight repeatedly at perfect right angles to the reference lines of sight permits accurate readings of horizontal distances to be made right on the "tooling bars," although the object being measured might be as far as 50 ft from the telescope. Special scales and verniers on the tooling bar setup permit measurements accurate to 0.001 in. within the grid system. The addition of a vertical tooling bar (F) and a jig transit (G) with a supersensitive, self-proving level makes possible vertical measurements of similar accuracy and provides perfect control of the third dimension. The basic installation can be further expanded to include other tooling bars, instruments, and equipment as required.

Thus, the operator can sight on a reference point on the object, move the transit square a definite distance along the tooling bar, project the cross wires onto the object at that point, then walk over to the object and mark the point himself. This cross-wire projection, which works well in normal room light, is effective up to 30 ft. with a high degree of accuracy.

Brunson optical-tooling instruments as used in both of these optical-tooling techniques are distributed exclusively by the Charles Bruning Company, Inc., Chicago, Ill.



The Brunson optical-grid method of measurement provides industry with a micrometer-accurate system of measuring, aligning, inspecting, and positioning large or small objects and for locating points. Two reference lines of sight (A and B) are established at right angles to each other and maintained by two alignment telescopes (C). Two horizontal "tooling bars" (D), placed along the lines of sight, provide a "track" on which the key instruments—the optical transit squares (E)—can be moved and positioned. Directed at the object being worked on, they provide lines of sight which are at precise right angles to the reference lines and can be elevated or depressed as required to line up with given points or to "sweep" vertical planes.



Titanium-Sponge Reactor. "Spalt," a combination of salt and titanium sponge, clinging to the sides of a reactor, is loosened with a huge product-removal machine at the Ashtabula, Ohio, titanium-sponge plant of Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation, largest titanium-sponge plant in the country. The plant has maintained capacity production for 45 days and is also the first in this country to use the sodium-reduction process on a commercial scale in reducing titanium tetrachloride.

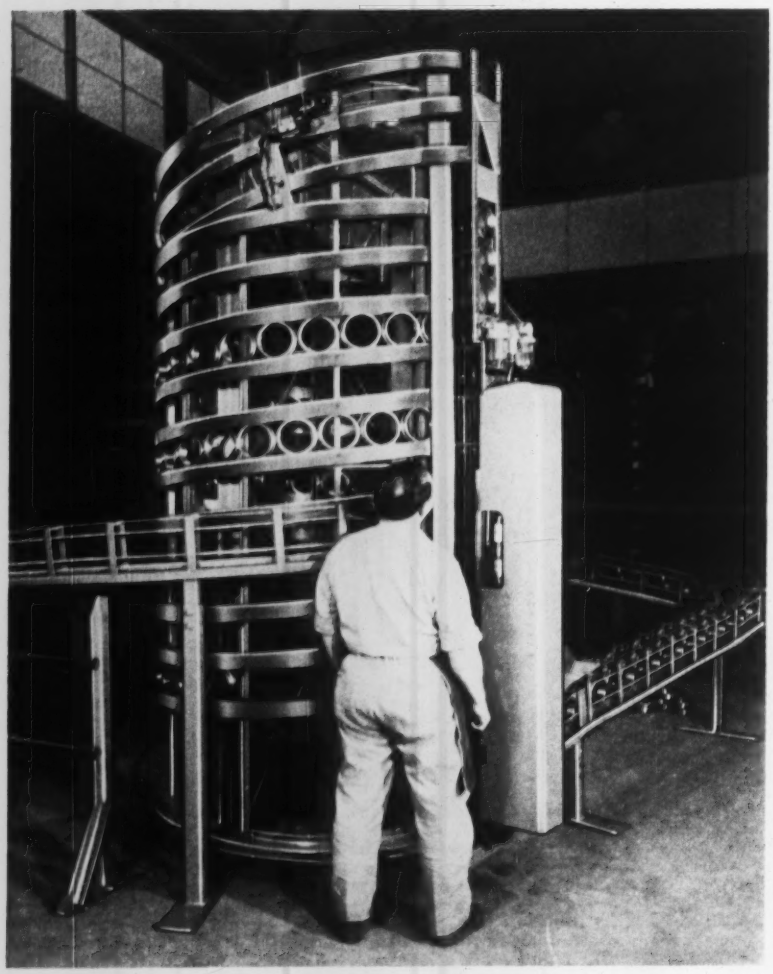
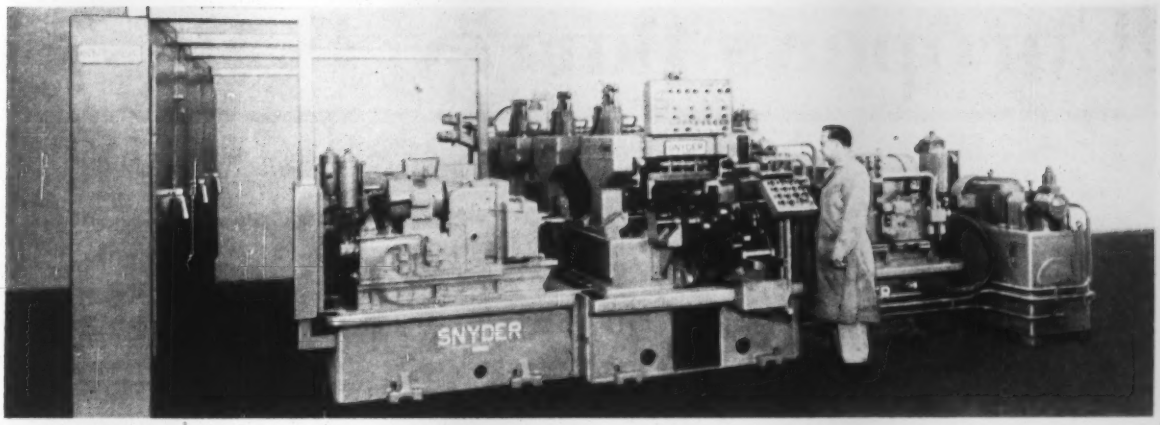


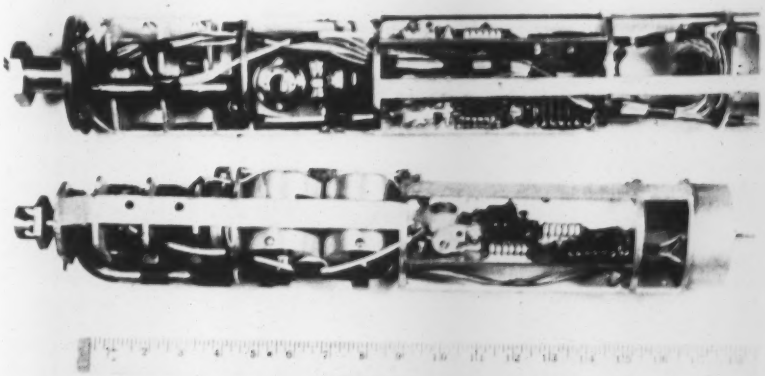
Photo Briefs

Rotary Storage. Rotary high-capacity storage unit for parts or blanks that can roll, developed by the Gear-O-Matic Division, Machine Tool Company, Detroit, Mich., for use in automated processing lines. An accept-reject device guides parts to the fully caged double track for gravity feed to the double-shaft elevator which carries them to the top of the unit. From there they roll down the circular track to the exit-chute take-off and are fed back into the line on demand by means of air-cylinder-operated gates.



Maintaining Concentricity. This 13 station, 4-segment transfer machine maintains concentricity of tapped holes with a bored center hole in forged-steel or cast-iron crankshafts. The drilling, boring, chamfering, reaming, and tapping operations are performed by the machine at the rate of 112 pieces per hr, and were previously done on trunnion-type special machines. Designed and built by Snyder Tool & Engineering Company, Detroit, Mich., the whole assemblage of three two-way machining units and one one-way unit occupies about $12\frac{1}{2} \times 17$ ft, and is hydraulically operated. Each unit has an individual control panel. Master panel controls the entire group and also indicates the condition of each segment.

Pressure-Measuring Instruments. Some of the small and rugged instruments which made up the first extensive pressure-measurement system to be completely contained within a pitot static tube. Accurate measurements of atmospheric pressure and density were made in a Navy Aerobee-Hi rocket at an altitude of 125 miles by these instruments designed and developed by the Decker Aviation Corporation of Philadelphia, Pa. The 26 oz of measuring instruments and 5 lb of electronic equipment functioned perfectly despite heat and vibration while the rocket was hurtling through space at more than a mile per sec.



Spotting Corrosion. A technique for locating possible internal corrosion in sealed, welded tubing developed by Holger Andreasen, Inc., San Francisco, Calif., has been adopted at Pan American World Airways. Through the use of portable equipment known as "Andrex," Pan American can x-ray large or fixed installations that cannot be conveniently or economically examined in an x-ray laboratory. In the examination shown, x-ray film is positioned above nose gear V-strut with tube head directly below and control panel removed to an operating distance.

European Survey

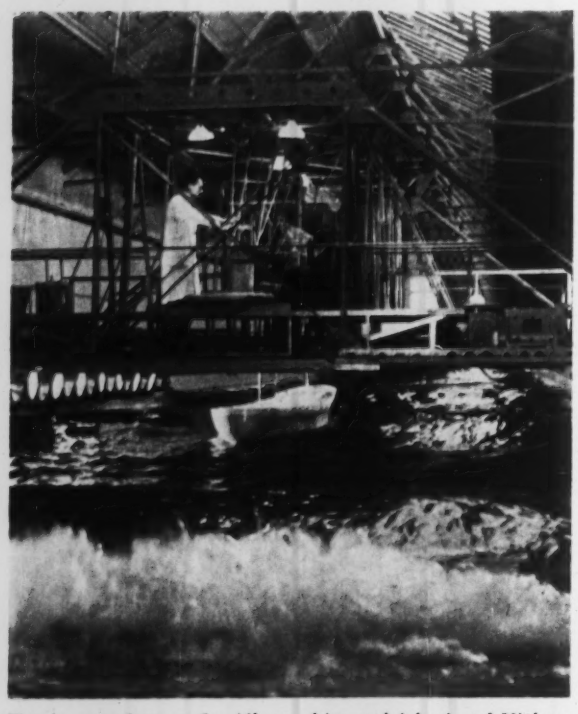
Engineering Progress in the British Isles and Western Europe

J. Foster Petree,[1] Mem. ASME, *European Correspondent*.

Re-Equipping a Ship-Model Basin

THE technique of predicting the power required to drive a ship from tests on a small scale model of the hull originated with an English inventor and scientist, William Froude, who persuaded the British Admiralty to authorize him to construct the first ship-model basin near Torquay, in the southwest of England, in 1870–1872. He did such good work there that a private shipbuilder in Scotland, William Denny, of Dumbarton, decided to build one of his own, which he did in 1883; it is now the oldest existing ship-model basin in the world. He was followed by John Brown & Company, of Clydebank, the builders of the *Queen Mary* and *Queen Elizabeth*, whose model basin dates from 1904; and by Vickers Limited (now Vickers-Armstrongs, Limited), who built one at St. Albans, to the north of London, in 1912. It is 447 ft 6 in. long, 20 ft 10 in. wide, and 11 ft 3 in. deep.

[1] Correspondence with Mr. Petree should be addressed to 36 Mayfield Road, Sutton, Surrey, England.



Towing carriage at St. Albans ship-model basin of Vickers Armstrongs, Limited. Waves are produced by a wave-making machine at the other end of the basin.

The St. Albans basin suffered considerable bomb damage during World War II, but was repaired and continued to play a considerable part in the testing of models for warships and also for aircraft. (Incidentally, it was at this establishment, during World War I, that the experimental work was done which led to the construction of the Vickers-Vimy airplane in which, on June 14-15, 1919, Sir John Alcock and Sir Arthur Whitten Brown made the first nonstop transatlantic flight; the aircraft is now preserved in the Science Museum, London.) Over the past ten years the equipment of the St. Albans basin has been completely modernized without more than temporary interruption to the work, and this long-term task has now culminated in the installation of a new wave-making machine, designed at St. Albans and made in the Vickers-Armstrongs shops at Newcastle-on-Tyne. It consists of a plunger of triangular section, of the full width of the basin and built of welded sheet steel, which is moved up and down in the water with a simple harmonic motion. The heights and lengths of the waves are controlled primarily by varying the amplitude and frequency of the motion, respectively. Waves can be made up to 2 ft high and 40 ft long, which more than covers, to scale, the severest conditions observed and measured at sea.

The speed control has been designed and made by the Metropolitan-Vickers Electrical Company, Manchester, England, and incorporates a flux resetting transductor and Ward-Leonard control, with either manual or automatic setting, which can give either constant speed or a repeatable sequence of varying frequencies, thus producing trains of either regular or irregular waves. The 100-hp motor can be controlled remotely from the model-testing carriage if desired. A wave-height recorder, designed and made at St. Albans, electronically measures the height of the water against a fixed probe and gives a continuous autographic record.

Rapid Analysis of Steel

A Swiss instrument for the rapid analysis of steel, as a means of production control, has been installed at the works of Samuel Fox & Company, Stocksbridge, near Sheffield, England. It is the first production model of a design developed by Association Research Laboratories, Lausanne, Switzerland, and is intended solely for the analysis of steel, including stainless steels and high-speed tool steels of the tungsten-molybdenum-chro-

mium-vanadium type. The Quantometer, as the instrument is named, is designed for the determination of 17 elements in ranges from a mere trace up to 30 per cent, and can provide an analysis for manganese, nickel, chromium, molybdenum, and copper in 10 to 15 minutes after taking a sample from the electric furnace. The actual analysis time is from four to five minutes; by ordinary chemical methods, it would take about an hour. The complete outfit consists of three units, namely, the multi-source unit, which creates excitation conditions across the analysis gap, causing sparklike or arclike discharges, as desired, to the sample under analysis; the spectrometer, which forms a spectrum from the light emitted by the discharge; and the recording console. Power for the source unit comes from a Schlinder motor-generator set, which gives stable voltage and frequency.

General view of the Quantometer at the Stocksbridge works of Samuel Fox & Company, Limited, showing, *left to right,* the recording console, the spectrometer, and the multi-source unit

In the spectrometer the wave lengths of the elements in the steel sample are isolated and their light energy is transformed into electrical charges. Selected wave lengths of the diffracted light are isolated by slits and focused by mirrors onto photomultiplier tubes. The recording console houses the high and low-voltage power supplies, integrators, amplifier, sensitivity controls, and switching circuits. The charges from the photomultiplier tubes are collected by integrator capacitors, sequentially switched to an amplifier, and then recorded on a high-speed recorder. The recorder system was not made by the Research Laboratories, but it is also Swiss, the makers being Trüb, Tauber A. G., of Zürich. Analytical curves are prepared from standardized samples, covering the range of contents required. During the few months that the Quantometer has been in operation at the Stocksbridge steel works, the reliability of the analyses has been found to be comparable with those obtained by the standard chemical procedures.

Aircraft Production Criticized

Some pointed criticisms of British—and, indeed, of European—policy in aircraft production were expressed by Dipl. Ing. Karl Frydag, chairman of the supervisory committee of the Deutsche Versuchsanstalt für Luftfahrt and a director of Henschel & Sohn, Kassel, Germany, when he delivered the Lord Sempill Paper to the Institution of Production Engineers at the Fifth Conference on Problems of Aircraft Production at Southampton, England, on January 8. The title of his paper was "Concentration of Aircraft Development" and his contention was that Britain, in particular, was dissipating effort and the limited available resources in technical manpower and production capacity, in trying to develop too many different kinds of aircraft at once. Early in World War II, he pointed out, Germany had decided to concentrate on the production of five types of aircraft (two fighters, one night fighter, and two bombers) and three types of engine (one of 35 liters, one of 48 liters, and an air-cooled engine), apart from a few special-purpose and transport craft. All the firms in the German aircraft industry were forced to conform to this program, which was planned from the start for mass production; his own firm (in the war years, he was with the Rohrbach Metall-Flugzeugbau, Berlin, and later in the Messerschmitt works at Augsburg) had to erect a works for a monthly output of 100 two-engined bombers.

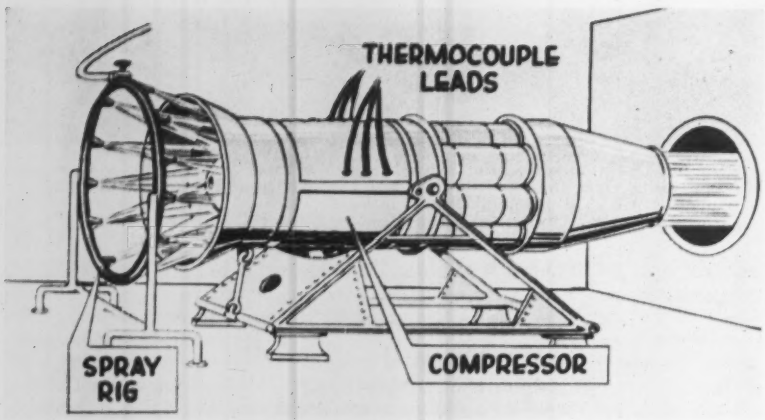
All went well, he said, until the German military leaders began to interfere with the program; in his own words, "interference resulting in substantial program alterations increased until it became improvisation." The consequence was that the monthly output for the whole industry was below 2000 aircraft at the beginning of 1944, in spite of all the preparations made for mass production; but when the authorities realized their mistake and cut down the number of types, the output rose so rapidly that, by September, 1944, it was 4800, even though, by that time, the industry was exposed to heavy bombing raids. Herr Frydag argued from this experience that the British industry should be equally drastic in reducing the number of types.

Britain, he declared, should concentrate, first, on transport aircraft, for both military and civil requirements; second, on not more than two types of fighters. In the latter field, he considered, the primary needs were for a fighter with supersonic speed and long range, and an interceptor fighter. Third, with regard to bombers, Britain should concentrate on the development of a supersonic bomber, and be content to build the conventional night bomber under license, to American designs. Finally, he said, "In co-operation with the United States of America or European countries, greatest importance should be devoted to the large field of guided missiles, either ground-to-air, air-to-air, or ground-to-ground."

Note: The January, 1957, issue of Mechanical Engineering inadvertently omitted a credit to *Engineering* for the illustration which appeared on page 45.

ASME Technical Digest

Substance in Brief of Papers Presented at ASME Meetings



Water spray rig which simulates rainstorm conditions by introducing water into compressor inlet of J47 turbojet engine

Aviation

The Effect of Heavy Rainstorms on J47 Turbojet Operation, by S. S. Wayne, Assoc. Mem. ASME, Jet Engine Department, General Electric Company, Cincinnati, Ohio. 1956 ASME Annual Meeting paper No. **56—A-151** (multilithographed; available to Oct. 1, 1957).

In designing and developing jet engines it is necessary that considerable attention be given to operational difficulties which might be encountered through weather conditions. Normal operation of both military and commercial aircraft requires that they be capable of peak efficiency and power in all atmospheric conditions. The Aircraft Gas Turbine Division of the General Electric Company initiated a test program to ascertain the effect of heavy rainstorm operation on compressor rotational clearances of the J47 turbojet engine.

A survey of meteorological data was made to determine the quantities of water necessary to inject into the engine to simulate flight under a reasonably wide range of weather conditions. Based on the data accumulated, water flow rates were chosen to simulate water concentration of from 3 to 60 g per cu m. This range is representative of all but the most unusually severe conditions, which normally would be avoided by the jet pilot.

Results of these tests and important facts about the design and operation of turbojet engines are presented.

All Cargo Aircraft Requirements for Efficient Ground Operation, by W. H. Arata, Jr., Fairchild Aircraft Division, Hagerstown, Md. 1956 ASME Annual Meeting paper No. **56—A-172** (multilithographed; available to Oct. 1, 1957).

Up to the present time, all commercially operated cargo aircraft are modifications from initially designed passenger transports. As a consequence, loading methods and tie-down practices have not been optimized. It is believed that the air-freight operators will realize additional benefits when aircraft designed primarily for air-cargo operation are introduced into service.

In reviewing design requirements as related to efficient ground operation, the material of this paper is divided into four phases—cargo loading, design, economics, and cargo trends.

Cargo loading is discussed with reference to floor location as related to loading methods, the integral loading devices. The design of the cargo aircraft is considered from the standpoint of power-plant selection, fuselage pressurization, and the performance effects. Profit being the primary object in the design of commercial transports, economics are also taken into account. Operating costs, fuel costs, and ground time are discussed. In conclusion, cargo transport trends are noted.

Oil and Gas Power

Future Developments of the High-Speed Diesel Engine, by E. Chatterton, D. Napier & Sons, Ltd., London, England. 1956 ASME Annual Meeting paper No. **56—A-141** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

It is a well established design fact that for fundamental reasons an engine having multiple cylinders of small dimensions running at a high rate of revolution can be made lighter and smaller for a given power output than one having a smaller number of larger cylinders running at lower speed. A "high-speed diesel engine," for the purpose of this paper, is one which is designed specifically with the object of exploiting this fact and achieving the minimum weight and space occupied per horsepower produced. The author examines the increase in power output from a given size of cylinder which results from the combination of a diesel engine and exhaust-driven gas turbine operating with high degrees of supercharge.

Three main objectives are discussed: (*a*) To show that development of the high-speed engine is justified on both technical and economic grounds, (*b*) to explore the lines of development which at present appear to offer the greatest possibilities for reduction of engine size and weight and consider the limitations which exist, and (*c*) to assess the relative suitabilities of various basic types for such developments.

The Development of a Supercharged Medium Speed Two-Cycle Opposed-Piston Engine, by A. K. Antonsen, Mem. ASME, Fairbanks, Morse & Company, Beloit, Wis. 1956 ASME Annual Meeting paper No. **56—A-99** (multilithographed; available to Oct. 1, 1957).

The $8\frac{1}{8}$-in. × 10-in opposed-piston engine has been in commercial production

for locomotives for 18 years; and for marine, stationary, and industrial applications for 10 years. As early as 1945, an experimental program for supercharging the engine was carried out. A continued supercharging research and experimental program has been in effect since 1952. This paper gives an account of the 1945 supercharging experiments and goes on to discuss supercharging developments between the years 1952 and 1956.

Although experimental work is still incomplete and the supercharger modifications not yet in commercial production, it is believed that the experiments to date have established the following facts:

1 The supercharging of the two-cycle, opposed-piston engine can be accomplished with manufacturing simplicity and operational dependability equal to or exceeding the four-cycle engine.

2 The best fuel economy of the supercharged two-cycle engine appears to be inherently better than four-cycle supercharged fuel economy. Experimental tests have proved that a 0.333 lb per hp-hr is possible for this medium-speed engine.

3 Major sudden load variations between 50 per cent and full load can be handled on a self-sustained basis without the aid of auxiliary-blower equipment. Starting and minor sudden load changes can be handled without the aid of auxiliary-blower equipment.

Gas Turbine Power

Aerodynamic Design of Vaned Diffusers for Centrifugal Compressors, by C. R. Faulders, Mem. ASME, North American Aviation, Inc., Downey, Calif. 1956 ASME Annual Meeting paper No. **56—A-213** (multilithographed, available to Oct. 1, 1957).

A CRITICAL problem in the design of centrifugal compressors is the diffusion of the high-velocity flow leaving the impeller to the velocity at which the flow is discharged from the compressor stage. Depending upon the particular application, the designer may use for this purpose a vaneless diffuser or a vaned diffuser, and either parallel, converging, or diverging side walls. The purpose of this paper is to present a critical analysis of the flow in a vaned diffuser with parallel side walls.

Experimental results obtained with a test rig having a steady, uniform inlet flow are summarized. Deficiencies in performance were found to arise from the use of blade-thickness and blade-camber distributions giving nonuniform blade loading, and from boundary-layer flowing along the wall and collecting on the pressure side of the blades. Particular attention is given to a comparison of passage-flow and cascade-flow design approaches and to the wall-boundary problem.

Test results are presented and a method of design for improved performance is postulated on the basis of the experimental data combined with analytical relationships relating boundary-layer cross-flow to diffuser geometry.

Measurements of Relative Flow Distributions in Mixed-Flow Impellers, by J. E. Ash, Assoc. Mem. ASME, Armour Research Foundation, Chicago, Ill. 1956 ASME Annual Meeting paper No. **56—A-205** (multilithographed, available to Oct. 1, 1957).

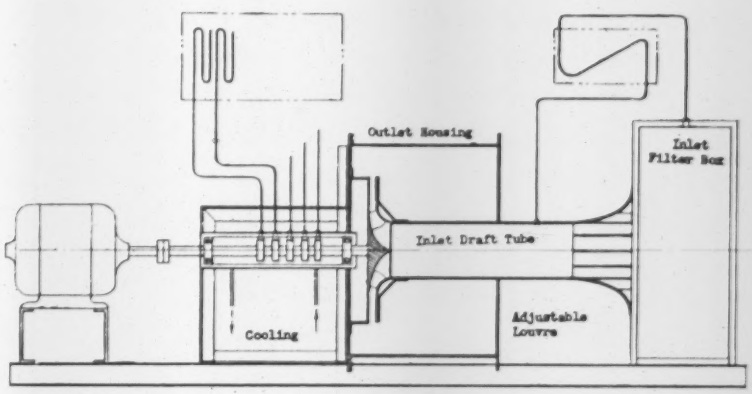
CONSIDERABLE progress has been achieved in the past for the one and two-dimensional methods of analysis as applied to radial-flow and axial-flow turbomachines. In mixed-flow machines, however, the three-dimensional effects are of relatively greater importance, and further knowledge is required of the detailed flow conditions. This paper presents results of experimental investigations of the relative flow in the rotating passages of a mixed-flow impeller. In an effort to supplement the existing experimental techniques, a three-dimensional, spherical pitot probe and a pressure-transfer device employing mercury seals have been developed for measurement of the relative flow fields within the rotating impeller.

Comparisons of the measured results are made with theoretically predicted results for the purpose of evaluation of an impeller-design method and also for the evaluation of a more exact quasi three-dimensional blade-to-blade numerical solution of the flow. Axial symmetry was assumed for the blade design and the fluid was considered to be nonviscous and incompressible. The blades were designed as bound-vortex sheets having a zero ring component of vorticity at the design point. The blade-to-blade solution was computed on the surface of revolution generated by the mean meridional streamline.

In regard to the experimental technique applied during the investigation, it can be concluded that consistent and reproducible surveys of the internal flow distribution can be obtained with a directional pitot probe mounted on the impeller and used in conjunction with a mercury-seal type of pressure-transfer device. The readings become unreliable if flow instabilities resulting from separation and eddy motion are present.

The Evolution of a Small Turbojet, by A. T. Gregory and J. A. King, Fairchild Engine Division, Deer Park, N. Y. 1956 ASME Annual Meeting paper No. **56—A-203** (multilithographed, available to Oct. 1, 1957).

THIS paper describes the development of the J44 engine. Design of the engine was initiated in 1947 to satisfy power-plant requirements of a low-altitude, air-launched guided missile. The primary requirements of the application were low cost, light weight, and reliability in power-plant package to produce approximately 900 lb thrust at low altitudes. The endurance necessary for the mission was a matter of minutes after which the engine was assumed to be expended, but extreme dependability during that period was essential. Because of



A schematic diagram of the test stand containing the 14-in-diam, mixed-flow impeller with four blades

the short flight duration, fuel consumption was of secondary importance. Details of parts fabrication, diffuser design, and compressor development are contained in this paper.

Mention is made, also, of a unique feature of the J44—its ability to withstand immersion in salt water. Results of tests showed that the J44 could be made salt-water proof by protecting critical parts from corrosion with phenolic coating, and by changing some materials and protecting others.

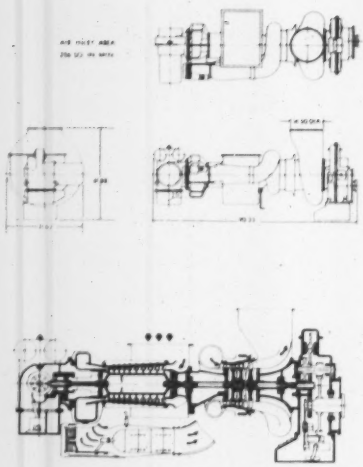
A 40-Ft Personnel Boat with Gas-Turbine Propulsion-Engine Installation Features and Operating Experience, by P. G. Carlson, Mem. ASME, and A. C. Ridland, Solar Aircraft Company, San Diego, Calif., and D. E. Blackwood, Assoc. Mem. ASME, Bureau of Ships, Washington, D. C. 1956 ASME Annual Meeting paper No. **56—A-210** (multilithographed, available to Oct. 1, 1957).

THE installation of a gas turbine for marine propulsion involves considerations not encountered with the more conventional reciprocating marine engines, and the performance of a gas turbine is undoubtedly influenced to a greater extent by installation conditions than is a reciprocating engine. The performance and, to some extent the handling of gas-turbine-propelled boats also differ markedly from those of similar craft employing reciprocating engines.

The number of gas-turbine-propelled boats that will be in military and civilian use is undoubtedly increasing. It is, therefore, considered of interest to report on certain installation problems encountered and operating experience gained on a particular boat of this type currently in operation. The 500-hp engine used in this craft, a 40-ft naval personnel boat, is believed to be the largest marine propulsion gas turbine installed and operating to date in this country. The engine was developed and the engine installation made by the Solar Aircraft Company under contract with the U. S. Navy Bureau of Ships. The service testing and evaluation are a joint program of these two agencies.

The conversion of the personnel boat to gas-turbine power is considered by the authors to be another step in proving the practicability of the gas turbine as a prime mover for small boats. While high first cost and relatively high fuel consumption per hp-hr limit the use of the turbine at present, there are certain applications where it is quite attractive.

Other factors which favor the turbine are: low empty weight (important for shipboard handling), reduced vulnerability to enemy fire, greater reliability, greater reserve power for short emergency sprints, and ability to start without warm-up equipment in Arctic weather. With the inevitable improvement in thermal efficiency of the gas turbine as development continues, this type of prime mover will find an ever-increasing range of marine applications.



A schematic representation of the gas-turbine-propelled engine configuration. The engine is of two-shaft construction, the two rotors are located end to end on the same axis.

Air and Gas Duct System for the Gas-Turbine Vessel John Sergeant, by W. A. Sherbrooke, Mem. ASME, Piping Specialties, Inc., New York, N. Y., and H. Monroe, Jr., Newport News Shipbuilding & Dry Dock Company, Newport News, Va. 1956 ASME Annual Meeting paper No. **56—A-207** (multilithographed, available to Oct. 1, 1957).

THE Liberty ship *S. S. John Sergeant* was converted by the Maritime Administration at the Newport News Shipbuilding and Dry Dock Company to gas-turbine power from reciprocating steam engine power. This was done as part of a Liberty Ship Conversion and Engine Improvement Program.

This paper describes the duct, dampers, and expansion joints of the inlet-air and the exhaust-gas system for the gas turbine of this vessel. The system involved is for a regenerative cycle with a waste-heat boiler. The limitations of space and allowable loads on terminal connections of equipment resulted in major problems in duct and expansion-joint design. The solution to these problems is described. An expansion joint was tested and a comparison is given of calculated and actual loads.

It is hoped that the performance of the GTV *John Sergeant* will encourage wider use of marine gas turbines. Much attention, however, will have to be given to the design of expansion joints in the ducts. If a small portion of the effort that has gone into the study of pipe stresses in recent years were devoted to the study of expansion joints, much of the mystery of expansion-joint stresses and loads could be removed.

Applied Mechanics

On Radial Deflections of a Cylinder Subjected to Equal and Opposite Concentrated Radial Loads (Infinitely Long Cylinder and Finite-Length Cylinder With Simply Supported Ends), by S. W. Yuan and L. Ting, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. 1956 ASME Annual Meeting paper No. **56—A-64** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

IN AN earlier paper, Mr. Yuan has obtained the radial deformations of a thin-walled circular cylindrical shell subjected to a pair of equal and opposite concentrated radial loads for the cases of infinitely long cylinders and cylinders of finite length simply supported at the ends. Based on the mathematical method given in that paper this problem is re-examined in the present paper using Flügge's equations. It is found that the results obtained in the earlier paper are quite satisfactory for short-length cylinders ($L/a \leq 10$) with simply supported ends, but not satisfactory for infinitely long cylinders.

On the Stress Distribution at the Base of a Stationary Crack, by M. L. Williams, California Institute of Technology, Pasadena, Calif. 1956 ASME Annual Meeting paper No. **56—A-16** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

IN AN earlier paper it was suggested that a knowledge of the elastic-stress variation in the neighborhood of an angular corner of an infinite plate would perhaps be of value in analyzing the stress distribution at the base of a V-notch. As a part of a more general study, the specific case of a zero-angle notch, or crack, was carried out to supplement results obtained by other investigators. This paper includes remarks upon the antisymmetric, as well as symmetric, stress distribution, and the circumferential distribution of distortion strain-energy density. For the

case of a symmetrical loading about the crack, it is shown that the energy density is not a maximum along the direction of the crack but is one third higher at an angle $\pm \cos^{-1}(1/3)$; i.e., approximately ± 70 deg. It is shown that at the base of the crack in the direction of its prolongation, the principal stresses are equal, thus tending toward a state of (two-dimensional) hydrostatic tension. As the distance from the point of the crack increases, the distortion strain energy increases, suggesting the possibility of yielding ahead of the crack as well as ± 70 deg to the sides. The maximum principal tension stress occurs on ± 60 deg rays. For the antisymmetrical stress distribution the distortion strain energy is a relative maximum along the crack and 60 per cent lower ± 85 deg to the sides.

A Theory of Adhesive Scarf Joints, by J. L. Lubkin, Assoc. Mem. ASME, American Machine and Foundry Company, Greenwich, Conn. 1956 ASME Annual Meeting paper No. **56—A-52** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

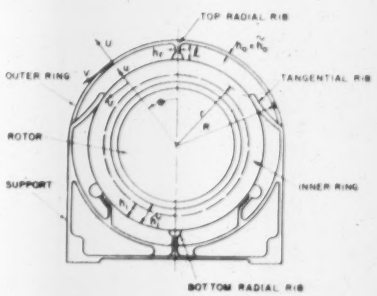
This paper establishes conditions under which a flat or tubular adhesive scarf joint can have uniformly distributed adhesive stresses, and gives formulas for these stresses. The results are rigorously limited to linear adhesive stress-strain relations, but are such that they sometimes may be applicable in analyzing scarf-joint tests to destruction, even when appreciable inelastic deformation occurs. Previously published test data are found to have one of the failure-load variations with scarf angle to be considered in this paper. The analysis therefore should prove useful in design work with the elastic limit, and in some cases beyond it.

Effect of Stress on Creep at High Temperatures, by H. Laks, General Electric Company, Detroit, Mich., C. D. Wiseman, O. D. Sherby, and J. E. Dorn, University of California, Berkeley, Calif. 1956 ASME Annual Meeting paper No. **56—A-55** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

Experimental investigations on pure aluminum and its dilute solid-solution alloys revealed that the high-temperature creep rate $\dot{\epsilon}$ is related to the stress σ by $\dot{\epsilon} \sim \sigma^n$ for low stresses and $\dot{\epsilon} \sim e^{\beta\sigma}$ for high stresses where n and B are constants independent of the creep strain and temperature. According to a preliminary dislocation-climb model for high-temperature creep, the activation energy for creep is that for self-diffusion and the effect of stress on the creep rate depends on the number of active Frank-Read sources, and the rate of climb depends on the structure as determined by the pattern of climbing dislocations. Many of the experimental observations on high-temperature creep can be accounted for by this model.

Vibration Modes of Stators of Induction Motors, by E. Erdelyi, Direct Current Motor and Generator Department, and G. Horvay, Mem. ASME, Metallurgy and Ceramics Research Department, General Electric Company, Schenectady, N. Y. 1956 ASME Annual Meeting paper No. **56—A-28** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

The increased emphasis placed on the design of "noiseless" machinery has led to the requirements of better evaluation of the magnetic attractive forces developed between rotor and stator of induction motors, better evaluation of stator response to such forces, and better evaluation of the sound waves radiated by the vibrating stator frame. This paper treats the crucial phase of the problem, determining the vibration characteristics of two concentric shells (stator core inside the stator frame) coupled by nonrigid ribs. The vibration theory of such coupled structures is developed and the theoretical results are compared with the experimental measurements obtained for a 30-hp, 3-phase induction motor. The agreement is within 7 per cent. Parts 1 and 3 of the problem, determination of the air-gap force waves and of the sound radiated, are discussed in separate papers.



Cross section of experimental motor. It consists essentially of a rather thin outer frame (the "outer ring") approximately cylindrical in shape, mounted on supports. A cylindrical inner core (the "inner ring") is connected to the outer shell by ribs. This core is made up of steel laminations parallel to the plane of the paper, in order to reduce the effect of eddy currents.

A Simple Procedure for Improved Accuracy in the Resistor-Network Solution of Laplace's and Poisson's Equations, by H. G. Landau, Columbia University, New York, N. Y. 1956 ASME Annual Meeting paper No. **56—A-13** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

The necessity for practical solutions of Laplace's and Poisson's equations arises frequently in engineering, for example, in problems of steady-state temperature, electric and gravitational potential, incompressible fluid flow, elastic torsion, and the other problems of elasticity. W. W. Soroka has shown that these equations can be solved by resistor networks. His work has shown that in solving the equation

$$\nabla^2 u = f(x,y) \qquad [1]$$

where $\nabla^2 u = \dfrac{\partial^2 u}{\partial x^2} + \dfrac{\partial^2 u}{\partial y^2}$

by a resistor network, it is possible to reduce greatly the lumping or truncation error by simply adding additional resistors to the usual arrangement, without any increase in the number of mesh points.

An Improvement of the Holzer Table Based on a Suggestion of Rayleigh's, by S. H. Crandall, Mem. ASME, Massachusetts Institute of Technology, Cambridge, Mass., and W. G. Strang, Rhodes Scholar, Oxford University, Oxford, England. 1956 ASME Annual Meeting paper No. **56—A-27** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

The calculation of torsional natural frequencies is considerably facilitated by a simple auxiliary computation used in conjunction with the well-known Holzer table. The procedure is described and illustrated and several practical suggestions are given. In many cases the total computation time can be cut in half by adopting this method. Mathematical justification for the process is given in the Appendix.

Some New Data on High-Speed Impact Phenomena, by J. H. Huth, Mem. ASME, and J. S. Thompson, Rand Corporation, Santa Monica, Calif., M. E. Van Valkenburg, University of Utah, Salt Lake City, Utah. 1956 ASME Annual Meeting paper No. **56—A-15** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

This paper presents a summary of some recent experimental work aimed at evaluating the role of various physical parameters in high-speed impact phenom-

ena. It is shown that penetration into thick targets by projectiles of the same material, for certain common metals, can be expressed approximately through a single relationship of the form $(p/d) = 2.5(V/c)^{1.4}$ in a range of about $0.1 \leq (V/c) \leq 1.0$. Here p represents penetration (crater depth) measured from the initial target surface, d a characteristic dimension of the projectile, and V the impact velocity. c is the "sonic" velocity in the projectile and target material as expressed by the formula $c = \sqrt{E/p}$, where E is Young's modulus and p the density. Experimental results are given for steel, aluminum, brass, lead, magnesium, and a magnesium-lithium alloy.

Response of Beams and Plates to Random Loads, by A. C. Eringen, Purdue University, Lafayette, Ind., 1956 ASME Annual Meeting paper No. **56—A-5** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

With the use of generalized harmonic analysis the problem of vibrating damped beams and plates under stochastic loading is solved. The resulting equations give the cross-correlation functions for displacements, stresses, moments, and so on, in terms of the cross-correlation function of external pressure. Mean square values of these functions are special cases of these results. Using a method due to Rice, we also calculate the probable number of times per time the random displacements or stresses will exceed a given value. The case of simply supported bars, cantilever bars, clamped circular plates, and simply supported rectangular plates are worked out in detail.

Experiments for the Determination of Transient Stress and Strain Distribution in Two-Dimensional Problems, by A. J. Durelli, Assoc. Mem. ASME, and W. F. Riley, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill. 1956 ASME Annual Meeting paper No. **56—A-11** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

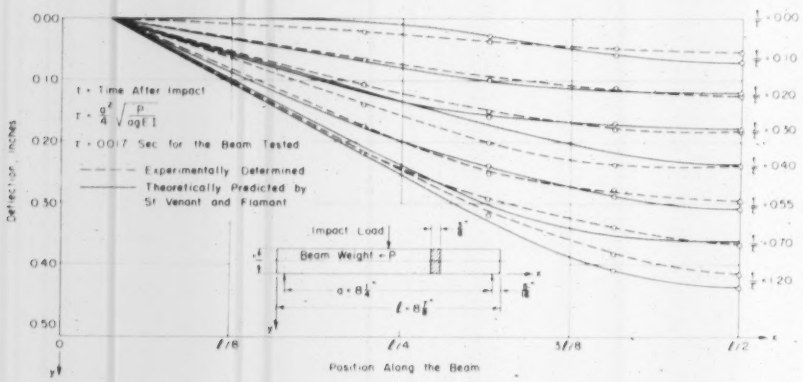
The object of this investigation was to develop a method utilizing photoelasticity for determining transient stress and strain distributions in two-dimensional problems. Numerous investigators have approached this problem using the common photoelastic materials which have a relatively high modulus of elasticity and correspondingly high velocity of wave propagation. However, many difficulties were encountered in photographically recording data, and only a few reliable stress patterns were obtained. In order to avoid these difficulties, a material with a low modulus of elasticity and a correspondingly low velocity of wave propagation was developed. As a result the 8-mm Fastax camera is capable of recording precise fringe patterns. The material used was a member of the epoxyresin family, modified to give the desired properties. Both its static and dynamic properties were determined as accurately as possible. It was found that the stain-fringe value of the material is approximately constant, but the modulus of elasticity and stress-fringe value are different for static and dynamic loadings. Preliminary studies were conducted to develop the method using a circular disk under a radially applied concentrated impact load as the model. A simply supported beam under central impact was then studied, and deflection curves obtained were compared with curves theoretically predicted by Saint Venant and Flamant. The comparisons showed good agreement. An analysis of the formation of the fringe pattern for various times after impact also was made.

The Effect of a Circular Hole on the Pure Twist of an Infinite Strip, by Osamu Tamate, Tohoku University, Sendai, Japan. 1956 ASME Annual Meeting paper No. **56—A-17** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

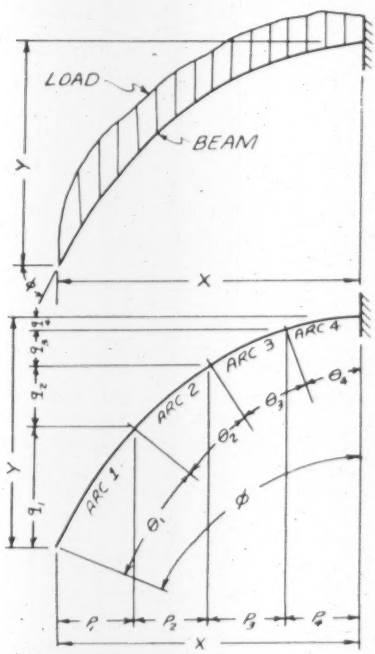
In a previous paper by the author, a theoretical solution for an infinite strip with a circular hole under plain bending is given by the method of successive approximation. This method demands laborious calculations. However, it seems that the labor can be diminished by employing the method of perturbation. In this paper, the effect of a circular hole in an infinite strip under the state of pure twist is investigated with the help of the perturbation method. The maximum deflections on the rim of the hole and the maximum stress couples in the strip are calculated and plotted versus hole-diameter strip-width ratio and Poisson's ratio of the plate material. Here the strip is considered subjected to the limitation of the Poisson-Kirchhoff theory of bending of thin plates.

A Numerical Procedure for Calculating the Large Deflections of Straight and Curved Beams, by A. E. Seames and H. D. Conway, Cornell University, Ithaca, N. Y. 1956 ASME Annual Meeting paper No. **56—A-38** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

This paper presents a numerical method for calculating the large deflections of



Experimental and theoretical deflection curves for a simply supported beam under central impact as a function of time (striker-beam weight ratio = 1; impact velocity = 55 ips)



Cantilever beam approximated by circular arcs

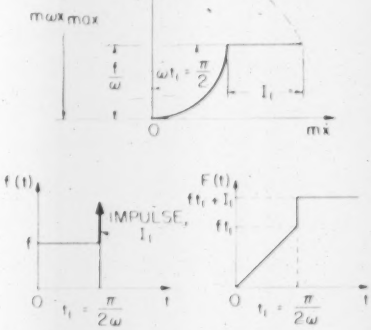
beams, assuming that the elastic axis can be approximated to by a number of circular arcs tangent to one another at their points of intersection. The calculations are made in tabular form, and are illustrated by particular examples of straight and curved cantilever beams and of rings subjected to concentrated or distributed loads. In those cases where an exact solution is possible, excellent agreement with the present method was obtained.

The Synthesis of Four-Bar Mechanisms by the Method of Components, J. Hirschhorn, New South Wales University of Technology, Sydney, N.S.W., Australia. 1956 ASME Annual Meeting paper No. **56—A-3** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

THE synthesis of four-bar mechanisms based on the vectorial representation of links in complex form was first suggested by S. Bloch. His work was further developed by R. Beyer and N. Rosenauer. These kinematicians investigated the synthesis of the four-bar mechanisms for prescribed instantaneous angular velocities and accelerations of the three moving links. This paper presents a somewhat different approach to the problem, in that the vectors are being resolved to Cartesian components. This method permits the synthesis for prescribed conditions concerning angular velocities, accelerations, and lengths of links. The author believes that the simpler treatment will make this method more rapidly acceptable to engineers.

Min-Max Solutions for the Linear Mass-Spring System, by E. Sevin, Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill. 1956 Annual Meeting paper No. **56—A-26** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

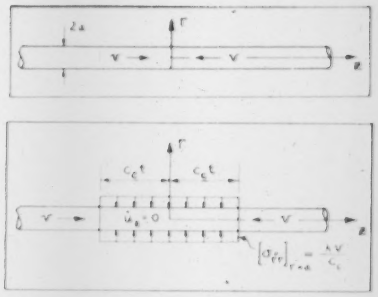
ABSOLUTE upper and lower bounds have been determined for the maximum displacement of an undamped linear mass-spring system acted on by a non-negative forcing function characterized only by total impulse and duration. The upper bound is shown to result from applying



Typical phase-plane trajectory for linear mass-spring system

the total impulse to the mass as an initial blow. The lower bound is shown to depend upon the ratio of load duration to natural period of the system, and this response results from a forcing function consisting of an initial and final impulse and an intermediate constant force. In the latter case, for sufficiently short durations, the forcing function reduces simply to equal initial and final impulses.

Longitudinal Impact of a Semi-Infinite Circular Elastic Bar, by R. Skalak, Columbia University, New York, N. Y. 1956 ASME Annual Meeting paper No. **56—A-37** (in type; to be published in the *Journal of Applied Mechanics;* available to Oct. 1, 1957).

THE impact of a semi-infinite elastic

Top: **The initial conditions of the problem considered are shown. Two semi-infinite circular bars, moving in opposite directions with speed v, are assumed to meet at the origin of z at time $t = 0$.** ***Bottom:*** **The second part of the solution is the response of an infinite bar, initially at rest and unstressed, to a radial traction applied to the surface of the bar, directed outward, and starting from the origin $z = 0$ at $t = 0$. This loading is chosen to be exactly the negative of the traction shown in the figure.**

bar of circular cross section is studied using the equations of motion of linear-elasticity theory and a method of double-integral transforms. An evaluation of the solution is obtained using approximations which are valid for large values of the time after the initial impact. The numerical results show a continuous dispersion of the wave front and an oscillation which are not found in the usual elementary-theory solution.

Safety

Toxicity of Materials—of Interest to the Mechanical Engineer, by J. B. Skinner, American Mutual Liability Insurance Company, Boston, Mass. 1956 ASME Annual Meeting paper No. **56—A-56** (multilithographed, available to Oct. 1, 1957).

THE toxicity of metals and materials used in connection with the formation, cleaning, and finishing of metals is described. Principal entry of toxic materials is through inhalation of dusts, fumes, mists, and vapors. Silicosis, lead poisoning, and irritation from aldehydes may occur in foundry operations. Welding and cutting operations involve hazards of poisoning from cadmium, zinc oxide, oxides of nitrogen, ozone, and fluorides. Lead and beryllium poisoning and dermatitis are connected with machine operations. Cleaning operations may develop irritation from alkaline materials and narcotic effects from solvent vapors. Exposure to alkaline mists, aromatic amino compounds, acid gases and mists and solvents are found in the finishing processes.

Industrial hygienists have expressed

the amounts of these materials which can be tolerated in the workroom atmosphere as maximum allowable concentrations. A table which summarizes the maximum allowable concentrations of certain gases and vapors; toxic dusts, fumes, and mists; and mineral dusts, is included.

The Human Factor in Machine Design, by Prof. T. F. Hatch, Mem. ASME, University of Pittsburgh, Pittsburgh, Pa. 1956 ASME Annual Meeting paper No. **56—A-46** (multilithographed; available to Oct. 1, 1957).

THE human factor in machine design is considered in this paper with particular reference to the design requirements to insure maximum safety for the operators of industrial machinery. Separate consideration is given to the two ways in which the human factor operates in accident causation. The first of these is the common human failure to work in a safe manner; and the second is the inherent accident potential of a job itself.

The necessity of minimizing the accident risk in the man-machine situation involves procedures of engineering analysis and design based upon an understanding of human behavior in response to external stress. Lack of an adequate body of systematic knowledge of human capacities and behavior for use by design engineers, however, makes this a difficult task.

In recent years, the growth of the science of human engineering has had direct and important application to engineering analysis and design for dealing with the human-stress problems associated with machine operation. In many cases quantitative relationships between external stress and human response may be demonstrated. A closer relationship between safety engineers, methods engineers, tool and machine designers, and bioscientists-anthropologists, physiologists, physicians, and psychologists is recommended.

Hydraulics

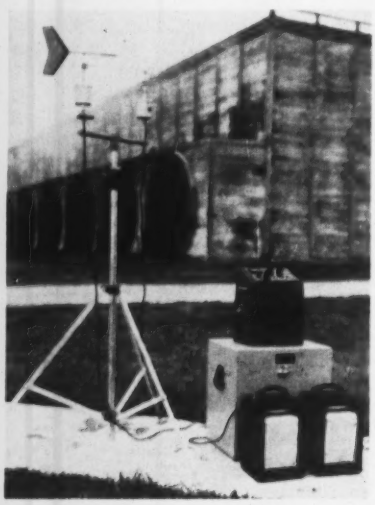
Accelerated Field Test of Cavitation Intensity, by R. T. Knapp, Mem. ASME, Hydrodynamics Laboratory, California Institute of Technology, Pasadena, Calif. 1956 ASME Annual Meeting paper No. **56—A-57** (in type; to be published in Trans. ASME; available to Oct. 1, 1957).

THIS paper describes a new technique for measuring the intensity of the cavitation attack in a piece of hydraulic equipment operating in the field, and presents the results and conclusions of a preliminary trial of this method in a 30,000-kw hydraulic turbine. This technique has been referred to as an accelerated test because the time required for the test run is measured in minutes, and by careful planning the total outage time required for installation and removal of the test plates is short.

Power Test Codes

Instrumenting a Field Study of Industrial Water-Cooling Tower Performance, by J. L. Willa, Palo Alto, Calif., and Technical Sub-Committee No. 2 of the Cooling Tower Institute. 1956 ASME Annual Meeting paper No. **56—A-22** (in type; to be published in Trans. ASME; available to Oct. 1, 1957).

IN PURSUIT of its objective "to advance the technology, design, and performance of industrial cooling towers," the Cooling Tower Institute undertook a comprehensive investigation of the several factors influencing tower performance. In the hope of developing either corrections or compensations for the loss of capacity due to changes in atmospheric conditions, including wind velocity and direction, a thorough study was made to determine the exact cause and magnitude of the losses on various sizes, types, and configurations of water-cooling towers.



Wind-speed and direction-recording station with strip-chart recorders in right foreground. Battery power pack is in base of control panel unit shown here on top of portable carrying case. All components except the tripod fit into protected compartments within the case for shipment and field handling.

Machine Design

The Use of Digital Computers in the Mechanical Design of Large Steam Turbines, by E. E. Zwicky, Jr., General Electric Company, Schenectady, N. Y. 1956 ASME Annual Meeting paper No. **56—A-139** (multilithographed; available to Oct. 1, 1957).

DIGITAL computers have had a profound effect on the entire design and development activity of steam-turbine manufacture. By providing a means for carrying out extensive calculations rapidly and economically, computers have made it possible to obtain more precise information on the structural behavior of turbine parts in time for this information to be used in design work. This paper describes computer applications to design of rotors, buckets, nozzle partitions and diaphragms, and analysis of temperature distributions and thermal stress. Additional means by which computers can be used to further reduce the manual effort necessary in a design organization are also discussed.

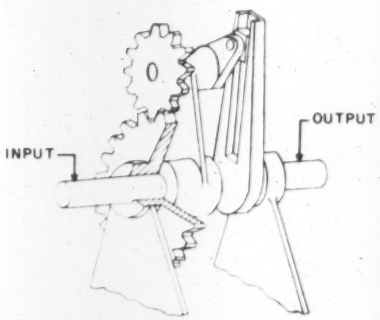
Application of Digital Computers to Bearing Design, by B. Sternlicht, General Electric Laboratory, and F. J. Maginniss, Analytical Engineering Section, General Electric Company, Schenectady, N. Y. 1956 ASME Annual Meeting paper No. **56—A-73** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

THE application of modern digital computing equipment to a study of the operating characteristics of journal and thrust bearings is described. Results of such a study are used in the design of these bearings. As originally programmed for the card-programmed calculator, approximations to the pressure distribution, side leakage, and total load in journal bearings were made under the assumptions of rigid bearings and constant temperature. Present development on the IBM type 650 magnetic drum calculator permits a more rigorous solution accounting for variations in viscosity and density of the lubricant, as well as any prescribed shape of the oil film. Faster and more precise solutions are possible both for thrust and journal bearings. In addition to the calculation of pressure, temperature profile, flow, and load results for the thrust bearing include a determination of the moments acting on the bearing sector, and a consequent locating of the center of pressure. A numerical example and a computer flow chart are included as guides to the design engineer. Operating techniques, and time and cost factors are discussed in order to illustrate

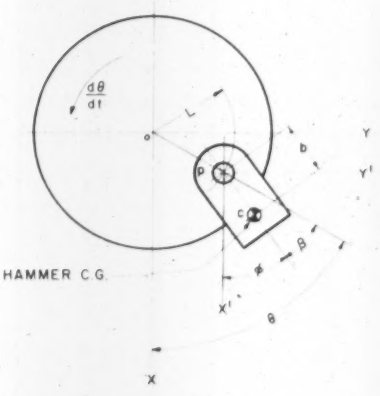
economic as well as engineering aspects of computer application. A derivation of the governing equations in dimensionless form is contained in an Appendix.

Two Applications of a Digital Computer to Machine Design Problems, by J. T. Lester, Jr., Assoc. Mem. ASME, Mechanical Development Laboratory, E. I. du Pont de Nemours & Company, Wilmington, Del. 1956 ASME Annual Meeting paper No. **56—A-98** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

THE ability of the high-speed computer to perform accurately and efficiently, simple arithmetic operations at an extremely high rate of speed makes it a useful tool for the design engineer. Examples are presented that illustrate two types of problems wherein a high-speed computer can provide important aid to the design engineer.



Perspective of simple cycloidal-crank drive. A device which produces a controlled periodic motion of an output shaft when the input shaft is driven at constant speed.



Hammer mill. Co-ordinate system for equations of motion.

The first example is representative of the tedious computations encountered in preparing tables. The mechanism involved in this study is called a "cycloidal-crank drive." It is a device that produces a controlled periodic motion of an output shaft when the input shaft is driven at constant speed. With the aid of the computer, the angular displacement, angular velocity, and angular acceleration of the output shaft, during one complete cycle of operation for many different combinations of design parameters, were obtained at a cost considerably lower than that required by older methods.

The second example is the solution of differential equations that describe the motion of a hammer mill. The hammer mill is a well-known device that is used for crushing ore, rock, limestone, and other materials. The purpose of the analytical phase of the study was to compute the motion of a hammer after it delivered a single blow. Of particular interest was the maximum value of the swingback angle and the period of the hammer swinging motion. This represents the "impossible" type of problem which the computer rendered solvable on a practical basis.

Steam Power

Metallurgical Considerations of Main Steam Piping for High-Temperature, High-Pressure Service, by H. S. Blumberg, The M. W. Kellogg Company, New York, N. Y. 1956 ASME Annual Meeting paper No. **56—A-157** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

A CONTINUAL need for a dynamic and expanding science of metals exists in all industries which utilize metals and this includes the steam-power industry. Such knowledge is being developed steadily and at present there is available considerable technical and scientific background for a number of compositions upon which the selection of steam-piping alloy steels can be based with excellent prediction of their service behavior. While much has been achieved, however, it must be recognized that many gaps still exist in the data required for a completely scientific treatment of the subject.

An approach to the problem of materials behavior and selection of main steam piping has been presented in which it is emphasized that detailed metallurgical considerations must be given to metals in all phases of processing, as well as in service, for fullest assurance of satisfactory performance. The importance of the role of the steam power plant engineer in making available service performance data has been stressed.

The historical and technical background of the currently used power-piping steels is reviewed broadly, with a summary of steels now generally specified for services up to 1050 F, and a summary of some promising compositions for higher temperatures.

Piping materials for power plants in which temperatures up to 1200 F are intended have been discussed specifically, with a discussion of the potentialities of superstrength alloys for main steam piping.

It is concluded that although a great many of these alloys are indicated to possess substantially greater long-time stress-rupture strength than Types 347 and 316 in the vicinity of 1200 F and higher, considerably more data are required regarding stability and weldability of these higher alloy compositions.

Available data for Types 347 and 316 and the superstrength alloys have been summarized for an evaluation of their potentialities for 1200-F service; the technical basis for the selection of Type 316 for the Eddystone Unit has been stated. At present, for contemplated service temperatures at which austenitic steels are considered, selection is made from Types 347 and 316, with the latter preferred; two important factors are that at higher temperatures Type 316 has received highest ASME Allowable Stress ratings, and that the material appears to possess better hot ductility properties.

The recent development of a weld-thermal cycle hot ductility test technique, for evaluating the hot cracking tendencies of austenitic steels, represents an outstanding metallurgical achievement. This test method gives promise of ultimate control of steel quality to a degree which will eliminate the weld joint-cracking difficulties experienced in the past.

The control of grain size of the austenitic steels is receiving increased attention. Although at present no steel producer appears willing to guarantee unqualifiedly grain size of such piping, studies are being continued which it is expected will result in the incorporation of this requirement into specifications.

In order to develop significant relationships between laboratory criteria currently used and actual service performance, it would be of considerable value, if during the procurement of piping, sufficient material from specific heats of steel used in particular installations was made available for thorough testing beyond

specification requirements. With the availability of such information, creep-rupture, stability, hot-ductility, and metallographic data on the actual material used in a unit could be compared directly with material performance under specific operating conditions.

Co-operation between the several engineering groups responsible for materials production, fabrication, and actual use is of paramount importance in advancing knowledge. Currently, a great deal of development work is being performed by producers and fabricators which should enable the steam-power industry to extend still further the frontiers of temperature, pressure, and rate of steam flow with resulting economic advantages.

Experimental Determination of Gear Tooth Stresses in Large Marine Gears, by H. W. Semar, Mem. ASME, and R. E. McGinnis, Assoc. Mem. ASME, Westinghouse Electric Corporation, Philadelphia, Pa. 1956 ASME Annual Meeting paper No. **56—A-117** (in type; to be published in Trans. ASME; available to Oct. 1, 1957).

THE problem of tooth breakage on large marine-propulsion gear units is prominent because of the serious consequence of the failure of a very small bit of material. Fortunately, these occurrences are rare, particularly in the case of merchant ship units of conventional design and materials. However, the extension of designs and materials to provide gears of greater power with less weight and space has been accompanied by incidents of tooth breakage.

These incidents have brought about an intensive reappraisal of the many factors which bear on the ability of pinion or gear teeth to withstand the duty imposed on them.

This paper describes an approach to the problem by actually measuring the stress in the root fillet of a pinion under operating conditions. It is emphasized, however, that the paper deals with one phase of the problem. It does not deal with the many other important factors which affect tooth strength.

Eight Years of Experience With Austenitic-Steel Piping Materials at Elevated Steam Conditions, by F. P. Fairchild, Fellow ASME, Public Service & Gas Company, Newark, N. J. 1956 ASME Annual Meeting paper No. **56—A-181** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

THE purpose of this paper is to give perspective to the problems incurred with the use of heavy-wall, austenitic-steel piping for service at elevated steam conditions, from the standpoint of the user.

When the decision was made to increase the throttle steam temperature of turbine-generators from 1000 to 1050 F, it was considered necessary to use materials with high-temperature properties superior to those of the low-chromium, ferritic alloys then in use for turbine valves and piping. The turbine manufacturers chose one of the grades of austenitic steel, AISI Type 347, 18 per cent chromium, 8 per cent nickel, stabilized with columbium. This material offered superior creep, and stress-to-rupture properties; better resistance to oxidation; was commercially available; and, since the codes assigned it relatively high allowable stress value, it enabled the designer to use thinner pipe walls which made it possible to provide greater flexibility to the piping system than could be attained with ferritic steels.

In three generating stations of Public Service Electric and Gas Company, austenitic-steel pipe is in service in the main steam systems of seven turbine-generator units, the first of which has been operating at elevated steam conditions since 1948. In all, there are now about 280 tons of this material in service in these stations. The record shows that there has been practically no trouble with this material, except at those locations where it is joined to other pieces of pipe, or attachments, by welding.

Basically, austenitic steels are good materials for heavy-wall steam piping operating at high pressures and temperatures. Much has been learned about them since they were first used for this service since 1948. The troubles have been analyzed, and many of them have been brought under control; others are under active study. The statistics shown in the illustration indicate that most of the welds that gave trouble were made by the early techniques, which have since been greatly improved.

Boiler Vibration Caused by Combustion Gas Flow, by John Halliday, Newport News Shipbuilding & Dry Dock Company, Newport News, Va. 1956 ASME Annual Meeting paper No. **56—A-216** (multilithographed; available to Oct. 1, 1957).

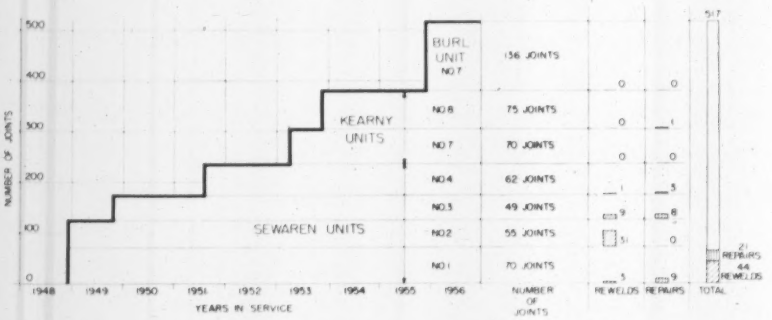
A SEVERE boiler vibration occurred during the dockside trials of a large ship's boiler. Previous analyses of a similar type of disturbance in a large land boiler had traced the trouble to self-excited vibrations which were caused by combustion gas flow over round struts in the boiler uptake, and which resonated with certain critical dimensions of the uptake. Calculations were performed to determine whether a condition similar to that in the land boiler might exist in the boiler under question. Shipboard tests were performed in order to be absolutely certain that blowers were not at fault.

Pressure pulses arising from the flow of combustion gas over the boiler economizer tubes were found to be the vibratory force involved. The frequency of the pulses was found to be the resonant frequency of the boiler uptake space immediately above the economizer. The resonant waves produced by this condition were broken up by the installation of a splitter in this area and the vibration thus eliminated. The minimum splitter length was determined by the fabrication of a 1/8-in. = 1 ft scale model.

Heat Transfer

New Finite-Difference Technique for Solution of the Heat-Conduction Equation, Especially Near Surfaces With Convective Heat Transfer, by H. G. Elrod, Jr., Assoc. Mem. ASME, Columbia University, New York, N. Y. 1956 ASME Annual Meeting paper No. **56—A-112** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

FINITE-DIFFERENCE methods have come into wide use for solving problems in-



A statistical diagram showing operating experience with welded joints in three generating stations of Public Service Electric and Gas Company

cluding transient-heat conduction. The possibilities of finite-difference methods have been ably presented by G. M. Dusinberre. The success of most such methods depends on the existence of a certain degree of uniformity of behavior of the temperature over the finite intervals of both space and time selected for the computation process. In some cases, however, this required uniformity constitutes a handicap since temperatures are changing so rapidly that inconveniently short time intervals have to be chosen. This paper represents an effort to develop a finite-difference method free from the foregoing defect.

The Determination of the Equation of State From Wave-Front Observations, by E. F. Lype, Mem. ASME, General Electric Company, Cincinnati, Ohio. 1956 ASME Annual Meeting paper No. **56—A-219** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

THE equation of state and the specific heat of a substance are related by certain differential equations to the pressure-density changes incurred by that substance under the influence of a rarefaction wave or a shock wave. These differential equations are derived, making it possible to obtain the thermodynamic properties from observations of the phenomena of wave propagation. In case of shock waves, this possibility results from the existence of a function, named the "Hugoniot function," which is constant on each compression curve and possesses the qualities of a property of state. A simple example illustrates the application of this method.

Convection Heat Transfer and Pressure Drop of Air Flowing Across In-Line Tube Banks, Part I—Apparatus, Procedures, and Special Effects, by C. E. Jones, Assoc. Mem. ASME, The Babcock & Wilcox Company, Alliance, Ohio, and E. S. Monroe, Jr., Mem. ASME, E. I. du Pont de Nemours & Company, Inc., Wilmington, Del. 1956 ASME Annual Meeting paper No. **56—A-126** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

THIS paper, the first of two companion papers, describes the equipment and computational methods used in an experimental program carried out at Cornell University, under the sponsorship of The Babcock & Wilcox Company. Eighteen arrangements of 10-row, in-line tube banks were tested for cross-flow heat transfer and flow-resistance performance, and sixteen additional arrangements were tested for flow resistance only. The interaction of transverse tube rows, the effect of tube-bank turbulence, the effect of temperature level, and the noise associated with some abnormally high flow resistances are discussed.

Rate of Temperature Change of Simple Shapes, by V. Paschkis, Mem. ASME, and J. W. Hlinka, Columbia University, New York, N. Y. 1956 ASME Annual Meeting paper No. **56—A-118** (in type; to be published in Trans. ASME; available to Oct. 1, 1957).

CHARTS have been prepared showing rates of temperature changes in simple shapes (the slab, the cylinder, and the sphere) plotted against temperature. Additional curves show time values, so that one graph yields any of the three relationships: Rate-temperature, rate-time, temperature-time. Samples of the charts are shown, examples of use are given, and limits of the graphs are tabulated. Methods used in establishing the charts are given.

Sublimation from Disks to Air Streams Flowing Normal to Their Surfaces, by H. H. Sogin, Assoc. Mem. ASME, Brown University, Providence, R. I. 1956 ASME Annual Meeting paper No. **56—A-115** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

MASS transfer by sublimation from 4-in-diam naphthalene disks to the stagnation regions of impinging jets of air was calibrated with heat transfer by convection in an identical configuration. Within the limits of the experimental reproducibility, all results were brought into a single correlation using Colburn's formulation of the heat-mass analogy. The calibration was then employed to obtain mean coefficients of heat transfer on disks with free edges. This part of the investigation was performed using two sorts of air streams; a 10-in-diam jet discharging freely into the atmosphere and a 5-ft-diam stream in a closed throat of a wind tunnel. The air speeds ranged from 22 to 293 fps, and the disks, made of naphthalene or of para-dichlorobenzene, were 2.25 and 4 in. in diam. The results of this part of the investigation may be represented by the equation

$$j \frac{GD_p}{\mu f} = 1.08$$

with a probable error of ±3 per cent. Including Powell's work on evaporation of water from disks, the equation covers a range of Reynolds number from 2000 to 600,000 with a maximum deviation of about ±10 per cent from the experimental points. The results of this work possibly may be of some general interest with regard to heat transfer at the stagnation region of a surface of revolution and perhaps may be of some use in dew-point or water-content instrumentation.

Convection Heat Transfer and Pressure Drop of Air Flowing Across In-Line Tube Banks, Part II—Correlation of Data for Ten-Row-Deep Tube Banks, by A. J. Gram, Jr., Assoc. Mem. ASME, The Babcock & Wilcox Company, C. O. Mackey, Cornell University, Ithaca, N. Y., and E. S. Monroe, Jr., Mem. ASME, E. I. du Pont de Nemours & Co., Inc., Wilmington, Del. 1956 ASME Annual Meeting paper No. **56—A-127** (multilithographed; to be published in Trans. ASME; available to Oct. 1, 1957).

NEW heat-transfer and pressure-drop data within a Reynolds number range of 600 to 40,000 obtained from model 10-row in-line tube banks are presented in a conventional form. The new data are compared with previously reported results for similar surface arrangements. By a process of cross-plotting, heat-transfer and pressure-drop factors are shown as a function of tube-bank arrangement in a series of curves at constant Reynolds numbers. Correlations for tube-bank geometry are proposed and the precision with which they represent the new and previously published data is discussed.

Metal Processing

On the Theoretical Analysis of a Dynamic Thermocouple, by E. W. Gaylord, Assoc. Mem. ASME, W. F. Hughes, Assoc. Mem. ASME, F. C. Appl, Assoc. Mem. ASME, and F. F. Ling, Assoc. Mem. ASME, Carnegie Institute of Technology, Pittsburgh, Pa. 1956 ASME Annual Meeting paper No. **56—A-86** (in type; to be published in Trans. ASME; available to Oct. 1, 1957).

THE "Dynamic" thermocouple formed by the moving junctions of two dissimilar metals is analyzed theoretically. It is found that if the two leads from the cold junction, in series with a potentiometer, are symmetrically placed in two bodies rubbing over each other, the emf measured by the potentiometer satisfies Laplace's equation in terms of the positioning of the leads in the body. The boundary condition is that the potential at any contact area is the Seebeck emf corresponding to the contact area temperature. It is shown that, in the case of two semi-infinite rubbing bodies with many randomly distributed

contacts, small in area compared to the distance between them, the potential measured by thermocouple leads placed at an infinite distance away from the contact areas is the average of the Seebeck emf's, corresponding to the contact temperatures, weighted by the square root of the areas.

Experimental and Theoretical Pressures and Velocity Fields for Various Lead Extrusions, by E. G. Thomsen, Mem. ASME, and J. Frisch, Assoc. Mem. ASME, University of California, Berkeley, Calif. 1956 ASME Annual Meeting paper No. **56—A-45** (in type; to be published in Trans. ASME, available to Oct. 1, 1957).

THE object of this paper is to present further studies of flow patterns in inverted extrusion processes of lead for various extrusion ratios and under variable lubrication for critical comparison with slip-line solutions. Such a comparison is deemed of considerable importance in order that these theoretical slip-line solutions may be brought to the attention of the practicing engineer, and that the potentiality for application to practice which these solutions hold may be fully utilized.

Extrusion pressures and velocity fields were determined for inverted extrusion processes of commercially pure lead. The extrusion ratios were varied from 1.51 to 18.5 (33.7 per cent to 94.6 per cent reduction). It was found that, for both low and high friction at cylinder wall and at die surfaces, qualitative agreement exists between slip-line solutions and experiment.

Rubber and Plastics

The Fundamental Mechanics of Reinforced Plastics, by J. Ogden Outwater, Jr., Assoc. Mem. ASME, University of Vermont, Burlington, Vt. 1956 ASME Annual Meeting paper No. **56—A-201** (multilithographed, available to Oct. 1, 1957).

A THEORETICAL approach to a better understanding of the behavior of reinforced plastic materials is presented. It is suggested that the governing factors in the behavior of reinforced plastics are the pressures exerted on the fibers by the polymerization of the resin, and the coefficient of friction between the fibers and the resin. This relationship was disclosed by a mathematical analysis of the interaction of the fibers and the resin under various conditions. By use of a mathematical model it was possible to evaluate the behavior of the fiber-resin structure under stress of varying magnitude. Using the hypothesis which resulted from this analysis it was possible to predict the stress-strain behavior of the specimen of reinforced plastics. To confirm this, previous results were studied in the light of the proposed theory, where real specimens of a glass reinforced plastic were subjected to loading and reloading fatigue stresses.

Electrical Effects Accompanying the Stick-Slip Phenomenon in Boundary Lubrication, by S. M. Skinner, Case Institute of Technology, Cleveland, Ohio, J. Gaynor, General Electric Company, Schenectady, N. Y., and G. M. Sohl, B. F. Goodrich Chemical Company, Avon Lake, Ohio. 1956 ASME Annual Meeting paper No. **56—A-163** (multilithographed, to be published in Trans. ASME, available to Oct. 1, 1957).

THE electrical transients which accompany the stick-slip phenomenon in boundary lubrication have been investigated. The apparatus used permits simultaneous oscillographic measurement during the stick-slip motion of any two of the following: The instantaneous load, the instantaneous frictional drag, the electrical transient potentials.

The phenomenon has been investigated with unlubricated metal-metal contact using four metals in various combinations, lubricated metal-metal contact using various combinations of metals and five lubricants, and metal-plastic contact. In all cases, the contact was a sliding contact at low speed, since this accentuates the stick-slip phenomenon. Definite time correlation between the mechanical stick-slip and the electrical transients has been found. The characteristics of the electrical discharge appear to favor a charge-discharge mechanism rather than a thermoelectric potential or a dielectric breakdown mechanism, although further experiments are necessary to provide unambiguous proof of such a conclusion. Certain related frictional experiments were performed which, however, also favor a charge-discharge mechanism.

High-Horsepower Banbury Mixing, by R. N. Comes, Farrel Birmingham Company, Inc., Ansonia, Conn. 1956 ASME Annual Meeting paper No. **56—A-195** (multilithographed, available to Oct. 1, 1957).

THE intricate mixing of plastic components in the compounding of plastics is one of the most important operations in the production of rubber and plastics. The Banbury mixer is used primarily for the breakdown or incorporation of pigments and fillers into rubber and plastic materials. A considerable amount of energy is required to achieve a homogeneous mixture, because of the heavy loads and impacting necessary to disperse uniformly the various types of materials used in the mixture. In order to improve the degree of mixing a study has been made of the effect of sequence loading, increased rotor speed, and increased pressure on the floating-weight cylinder.

Such changes, however, have increased the problems for both the user and the manufacturer of such mixing machines. Increased horsepower is required, and consequently larger motors, stronger frames for supporting the mixer, and redesign of the drive mechanism must be considered. For the user, it may mean the incorporation of automatic devices for feeding and loading the high-horsepower machines, in order to obtain maximum utilization of the equipment.

Penton—A New Chlorine-Containing Polyether, by E. W. Cronin, Hercules Powder Company, Wilmington, Del. 1956 ASME Annual Meeting paper No. **56—A-182** (multilithographed, available to Oct. 1, 1957).

PENTON is a chlorine-containing polyether, of a unit structure similar to that of pentaerythyritol. The chlorine is attached as a chloromethyl group which in turn is connected to a neo-pentyl carbon, thus making for a chemically stable chlorohydrocarbon. The uniqueness of the polymer lies in its combination of properties, rather than any single property. Outstanding among the properties cited, were:

1 High fabrication temperature up to 550 F.

2 Good melt flow resulting in good moldability from low melt viscosity.

3 Low mold shrinkage as a result of a highly crystalline structure and low volume changes from liquid to solid, therefore producing close mold tolerances.

4 Minimum strains in the molded specimen with low shrinkage and ability to distribute stress.

5 High dimensional stability and low H_2O absorption.

6 Good chemical resistance to most agents.

7 Good electrical resistance maintained over a wide range of humidity and temperature.

On an over-all basis, this polymer appears to be equal or superior to most of the other fluoro and chloro-hydrocarbon polymers. Suggested uses for the new polymer included (*a*) valve material for

high chemical and heat resistance, (*b*) wedges and slot liners for stators in enclosed refrigerator motors, and (*c*) ball-bearing retainer rings because of the dimensional stability of the material. The polymer is now undergoing further development studies for a more complete evaluation, before any possible commercialization is planned.

Roll Bending Applied to Rubber and Plastic Calenders, by R. C. Seanor, Mem. ASME, Adamson United Company, Akron, Ohio. 1956 ASME Annual Meeting paper No. **56—A-176** (multilithographed, available to Oct. 1, 1957).

In the past, various methods of roll bending or inducing a deflection into a calender roll by applying a bending moment have been tried without success. The latest means devised to enable the operator to change the effective crown of the rolls during operation of the calender is the roll bender. The roll bender discussed in this paper is a relatively simple device, consisting of auxiliary bearings mounted outboard of the main journal bearings, and loaded sufficiently by hydraulic cylinders or other means.

This device has made it possible for the purchaser of calender equipment to provide the necessary crown compensation at a minimum cost. The use of the roll bender for crown compensation also eliminates the ox-bow problem present with the use of roll crossing.

The only disadvantage of roll bending is that the amount of crown compensation is limited to the range between 0.004 in. and 0.006 in. on the average calender roll.

For calenders already installed, those used for plastic stocks can be readily modified by the addition of a roll bender without much alteration to the machine. With rubber calenders which require new rolls and a relocation of the drive, simple modification is not possible.

ASME Transactions

The February, 1957, issue of the Transactions of the ASME (available at $1 per copy to ASME members; $1.50 to nonmembers), contains the following technical papers:

Some Experiments on the Influence of Various Factors on Drill Performance, by D. F. Galloway. (56—SA-18)

Seal Leakage in the Rotary Regenerator and Its Effect on Rotary-Regenerator Design for Gas Turbines, by D. B. Harper. (55—A-109)

Mass-Transfer Cooling in a Laminar Boundary Layer With Constant Fluid Properties, by J. P. Hartnett and E. R. G. Eckert. (55—A-108)

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Comments on Papers

Including Letters From Readers on Miscellaneous Subjects

Metal-Cutting Analyses

Comment by C. Norman Fletcher[1]

I HAVE read with considerable interest the paper entitled "Review of the Metal-Cutting Analyses of the Past Hundred Years" on pages 715–721 of the August, 1956, issue of MECHANICAL ENGINEERING, and I would congratulate I. Finnie on his comprehensive research as exemplified by the bibliography.

I would, however, suggest the addition of four more references to the work, particularly of J. T. Nicholson (who is mentioned in reference 34), and his successor, Dempster Smith (mentioned in reference 35). Involved in the relevant discussions are contributions by the late Edward G. Herbert, founder of Edward G. Herbert Ltd., in 1892, who is mentioned in references 40 and 53, and was at one time a Member of ASME.

The Manchester Association of Engineers, currently celebrating its centenary, publishes Transactions regularly. The reports on some of Dr. Nicholson's and Professor Smith's research on this subject were published in the Transactions of this Association.

In particular, the "Report on Experiments With Rapid Cutting Steel Tools," made at the then Manchester Municipal School of Technology, under the auspices of a Joint Committee of members of the Manchester Association of Engineers and of members of the School of Technology Subcommittee together with Dr. Nicholson, professor of mechanical engineering at the afore-mentioned school, and prepared by Dr. Nicholson, Manchester Association of Engineers Transactions, 1903, p. 225.

"Lathe Tools" based on the report of the Lathe Tools Research Committee and published by the Department of Industrial Research (H. M. Stationary Office), and discussed before the Manchester Association of Engineers Transactions, 1922–1923, p. 357.

"Some Hardness Observations of a Tool Steel and Cutting Trials With Extremely Fine Cuts," by Dempster Smith, MBE, and Israel Hey, MSc. Tech., Manchester Association of Engineers Transactions, 1923–1924, p. 201.

"Second Report of the Lathe Tool Research Committee," by Dempster Smith, MBE, Manchester Association of Engineers Transactions, 1924–1925, p. 337.

[1] Director, Edward G. Herbert Ltd., Atlas Works, Levenshulme, Manchester, England. Mem. ASME.

Author's Closure

The author thanks Mr. Fletcher for his comments and for the additions to the bibliography.

Iain Finnie.[2]

U. S. Industry

Comment by Edwin P. Nye[3]

THE author has done an excellent job[4] in demonstrating the basic differences between production incentives in the United States as compared to those in other countries. However, I believe that his analysis does not go deep enough to emphasize the fundamental reasons for these incentives. It seems to me that if he rests his case on the fact that "in America, we mechanical engineers working with our foremen and labor have achieved a system whereby the products of our factories are actually available to all the people, in contrast to the situation in Russia where the factory products are theoretically available to all but actually are unobtainable," he has failed to indicate clearly why the Russian system as presently operated cannot and will not overcome this difficulty in the foreseeable future.

I believe that we in this country have developed our system of free enterprise as the result of our cultural and moral heritage of the Judaic-Christian tradition. This tradition recognizes the intrinsic importance of and the inalienable rights of the individual. The growth of our free enterprise system and of our independent labor movements has been sparked by an unshakable belief that the individual was created a free man with the *right* to pursue happiness and to enjoy the fruits of his labor. Under the communist system such individual rights are *denied*. Consequently, under the communist system, the motivations needed for high productivity are not possible, and no amount of state glorification or systemization can fully replace them.

Russia may ape our production *methods*, but without a moral philosophy which can generate individual incentive she cannot beat us at our own game. The greatest danger to the American way of life stems not so much from foreign competition as from our own tendency to forget and to neglect the real sources of our strength.

[3] Engineer, Shell Development Company, Emeryville, Calif. Assoc. Mem. ASME.

[4] "Why Is U. S. Industry Strong?" by W. A. Hadley, MECHANICAL ENGINEERING, vol. 78, September, 1956, pp. 820–822.

Comment by C. Lowell Harriss[5]

THE author's comparisons, as an engineer, of European with United States manufacturing are generally similar to those I, an economist, would make. Perhaps the fact that we were together part of the time accounts for some of the similarity.

One point of emphasis might find us differing. I am by no means certain that the American is as much more materialistic than the European as the author believes. I would be inclined to say that the more significant contrast has been the greater opportunity in this country for satisfying material desires. There has been more point in working, saving, taking risks, moving from home or job to another, and so on. The things that have made this difference in opportunity comprise a large part of the answer to our problem.

Mass education has played an important role. The author emphasizes an aspect of this feature of our economy too rarely noted. Vastly more Americans than Europeans get what might be called intermediate formal education and training—what is done in our high schools. It was when the director of research for Phillips emphasized this point to me that I began to observe it more con-

[5] Associate Professor of Economics, Columbia University, New York, N. Y. Author, "The American Economy" and numerous other books and articles.

[2] Associate Professor, Mechanical Engineering, The Pennsylvania State College, University Park, Pa. Mem. ASME.

sciously in Europe. From the point of view of the abilities needed to run a factory, or office, or railroad, or store, the training provided by public schools has given American business a real advantage over European.

An American economist is likely to attach considerable importance to a point not mentioned by the author: our antitrust program. It has many defects, but despite weaknesses it has prevented throughout large sectors of the American economy the kind of clubby co-operation among businessmen found so widely in Europe, co-operation which restricts price (and other) competition. In view of prospects of greater business profit, at least in the short run, and easier life, from business agreement to fix prices, and to restrain trade in other ways, the public needs protection. This country has much more such protection against restrictive monopolistic practices than Europe. One result is that businessmen have been forced to keep forcing each other to do better.

The availability of capital, and the willingness of management to scrap equipment which still functions but which is inferior economically to something newer, seems to be substantially greater in this country than abroad. (I gather, however, that many firms in this country are still backward in this respect.) His point about product design in respect to cost could be applied here in terms of design of the factory (or other) process and equipment. What is the cheapest way from now on? If it involves scrapping the magnificent machine installed last year, the right decision may seem hard. Yet the willingness of the businessman to do so means much in the progress of technology and of the economy as a whole. It is my impression that this characteristic is more common here than in Europe.

My final comment relates to the author's closing remark about the Russian threat. One reason this threat is so great in the economic sphere is the tremendous portion of national output devoted to industrial expansion. The low standard of living in Russia results in part from a deliberate decision of central authorities to force the public to sacrifice consumption for growth in plant and equipment. (Relatively much less of total new capital formation goes into housing than in this country.) Half a generation of forced plowing back of output into more productive capacity at the Russian rate may make our free choices to consume as much as we do very costly in terms of our relative productive capacity.

Reviews of Books

And Notes on Books Received in Engineering Societies Library

An Anthology of Standardization

NATIONAL STANDARDS IN A MODERN ECONOMY. Edited by Dickson Reck. Harper & Brothers, New York, N. Y., 1956. Cloth, 6½ × 9½ in., tables, index, xii and 372 pp., $5.

Reviewed by F. S. Blackall, jr.[1]

THIS volume, a joint undertaking of the Mellon Foundation and the American Standards Association, is a scholarly attempt to review, analyze, and forecast the trend of the standardization movement and make it better understood through a series of 33 essays on various phases of standardization. Among the authors, one finds such distinguished names as Herbert Hoover, Howard Coonley, Thomas D. Jolly, Brig. Gen. William H. Harrison, and Walter Reuther.

The philosophy of standardization, as exemplified by the ASA in this country and by the ISO across the world, has been spelled out by the editors and authors at some length. So have the techniques which have been found most effective for the sound and expeditious development of standards by groups, representing users, producers, and government. The whole has been correlated with the assistance of a competent editorial advisory board, comprising R. A. Brady, professor of economics, University of California; E. R. Weidlein, President of the Institute of Industrial Research; and Vice Admiral George F. Hussey, Jr. of the ASA.

The work is divided into three sections: the first dealing primarily with the historical aspects of standards; the well-documented second section, with specific applications and examples; part 3, with the impact and implications of the adoption of standards upon our national economy and international relationships.

Such an ambitious undertaking as this should become an invaluable reference work for students, engineers, and others who are seeking guidance in the ever widening quest for efficiency, safety, and human satisfaction through the creation and promulgation of standards. Like most anthologies, however, the work lacks the continuity and coherence which would be afforded by an all-embracing, single-minded study of the standards movement. For this reason, it suffers in spots from a lack of readability. The volume is one which the reader will prefer to pick up and lay down at will, rather than to attempt to consume in a single reading.

This reviewer found the historical section the most interesting part of the work. One tends to view standards purely as a modern phenomenon. The authors and editors bring the point home forcibly that "standards are as old as man," having crystallized gradually in the guise of folkways, mores, and patterns of behavior, the spoken word—language itself—being perhaps the oldest standard of all. The lack of a universal language and the never ending quest for a world-wide means of communication have their parallel in the international standards movement, in which some of the authors represented in this volume have played such a conspicuous part.

The main section of the work, dealing with the problems solved or awaiting solution in various and often unrelated fields of endeavor, will be of special interest to those members of the engineering profession who are engaged in stand-

[1] President and Treasurer, The Taft-Peirce Manufacturing Company, Woonsocket, R. I. Past-president and Fellow ASME. 1956 ASA Howard Coonley Medalist.

ards activities themselves. It should be on the book shelf or in the library of every member of the Standards Committees which are discharging one of the most important service functions of the Founder Societies.

Part 3, in particular, and some of the latter portions of part 2 paint the standards movement with a somewhat broader brush. A few of the contributors seem to wander a bit far afield from what engineers, at least, conceive to be a proper definition of standards in the modern sense. Reuther, for example, rejects the objective technical approach to time-and-motion study as something which should be discarded in favor of more subjective procedures. There is a thought-provoking chapter on the legal problems which confront industry under the Sherman Act in seeking uniformity of product. The methods followed by consumer-product rating agencies are interestingly described in a chapter of part 2, written by Arthur Kallet of the Consumers' Union. One senses a growing recognition in such areas of the need for sound laboratory and statistical procedures in making relative determinations of quality and performance.

Summary: A certain lack of readability is richly compensated for by the broad comprehensiveness of this volume, which will permit the casual reader to select or reject at will those areas which engage or fail to engage his interest. A laudable and ambitious attempt to evaluate and describe the vital place which industrial standards play in world economy. A worth-while textbook for tyro and veteran alike, who are engaged in creating new standards. A valuable reference work for student and engineer.

Books Received in Library

AIR POLLUTION HANDBOOK. Edited by Paul L. Magill and others. 1956, McGraw-Hill Book Company, Inc., New York, N. Y. Various paging, 6 × 9¼ in., bound. $15. Comprised of 16 self-contained sections, each accompanied by a list of references, this handbook provides basic source material on both theoretical and practical aspects of the causes, effects, and control of air pollution. It deals with such topics as city planning; plant location; the chemistry and physics of the atmosphere; effects on man, plants, and animals; sampling procedures; analytical methods; equipment for abating pollution; and legislation. Each of the sections has been prepared by an authority in the subject covered.

APPLIED METALLURGY FOR ENGINEERS. By Malcolm S. Burton. 1956, McGraw-Hill Book Company, Inc., New York, N. Y. 407 p., 6 × 9¼ in., bound. $7.50. The larger part of this text for a survey course for nonmajors consists of concise descriptions of metal-processing methods, with emphasis on principles but with considerable attention paid to modern techniques of casting, metalworking, welding, heat treatment, and powder metallurgy. Brief discussions of the nature of metals, methods of production, test methods, and the nature of alloys and alloying are also included, and equilibria diagrams are considered in some detail.

CHROMIUM. Volume 2. Metallurgy of Chromium and Its Alloys. By Marvin J. Udy. A.C.S. Monograph No. 132. 1956, Reinhold Publishing Corp., New York, N. Y. 402 p., 6 × 9¼ in., bound. $11. This volume deals with American and European methods of recovery, electrowinning, electroplating, and various methods of deposition, giving a considerable amount of detailed, practical operational data. It also deals fully with the production of ductile chromium, chromium in refractories, and the properties and uses of the metal and its alloys with iron, steel, cast-iron, cobalt, nickel, aluminum, copper, and titanium. Phase diagrams of a number of metals are included, and extensive reference lists accompany each chapter.

THE FATIGUE OF METALS. Published 1956 by The Institution of Metallurgists, London S.W.1, England. 148 p., 5½ × 8¾ in., bound. 17s.6d. This book contains a general discussion of fundamentals and four lectures devoted to the effect on fatigue of notches, surface finishes, etc.; structural aspects of aircraft fatigue; corrosion fatigue; and the effect of temperature on fatigue properties. At the end of the book is a tabulation of fatigue data on a number of alloys.

GLOSSARY OF TERMS RELATING TO RUBBER AND RUBBER-LIKE MATERIALS. (Special Technical Publication No. 184.) 1956, The American Society for Testing Materials, Philadelphia, Pa. 121 p., 6 × 9 in., paper. $3. A list of over 2000 terms of materials, processes, machinery, instruments, etc., relating to rubber, polymers, and resilient plastics. Trade names of apparatus and chemicals are given in an appendix.

MACHINE DESIGN. By J. E. Shigley. 1956, McGraw-Hill Book Company, New York, N. Y. 523 p., 6 × 9¼ in., bound. $7.75. Part one of this two-part text deals with basic design factors such as stress, deflection, and materials. Part two applies the principles discussed in the first part to the design of fasteners, springs, bearings, gears, and other common machine elements.

MEMOIRS OF THE UNIFYING STUDY OF THE BASIC PROBLEMS IN ENGINEERING SCIENCES BY MEANS OF GEOMETRY. Volume 1. Published 1955 for the Unifying Study Group by Gakujutsu Bunken Fukyu-Kai, Tokyo. 590 p., 7⅜ × ⅜ in., bound. (Approximately) $12.50. The papers produced by this research group are intended to demonstrate the application of tensor theory and geometrical-topological concepts to practical engineering problems. Stemming from Kron's work on electrodynamics this project has been expanded to cover in this volume not only electromagnetism and electric networks, but also elastic deformation, stress fields, crystal structure, plasticity and yield points, aerodynamics, and dynamics of granular media, dynamical systems in general, and tension-field theory. Subsequent volumes will further extend the scope of the work, which it is hoped will provide topics for future investigation rather than be considered as essential solutions along any line.

MOLYBDENUM. (Metallurgy of The Rarer Metals Series, No. 5.) By L. Northcott. 1956, Academic Press Inc., New York, N. Y. 222 p., 5½ × 8¾ in., bound. $6.80. A summary of available information, with special emphasis on physical metallurgy, and with particular attention given to the low oxidation resistance of molybdenum and to its embrittlement at low temperatures. The book covers extraction, properties, alloy systems, power metallurgy, fabrication, protective coating, and joining. References are listed after each chapter.

NATIONAL STANDARDS IN A MODERN ECONOMY. Edited by Dickson Reck. 1956, Harper and Brothers, New York, N. Y. 372 p., 6⅛ × 9½ in., bound. $5. Comprised of a series of articles by well-known authorities, this book is an examination and assessment of the standards movement as a whole within the United States. The articles deal with both the history of the movement and with applications of standards in specific fields: interchangeable parts manufacture, supply and purchasing, telecommunications, agricultural products, military goods, consumer goods, etc. A review of the international standards movement is included, and a number of articles are devoted to the implications of standardization for management, labor, and the consumer.

ORDINARY NON-LINEAR DIFFERENTIAL EQUATIONS IN ENGINEERING AND PHYSICAL SCIENCES. By N. W. McLachlan. Second Edition, 1956. Oxford University Press, New York, N. Y. 271 p., 6 × 9½ in., bound. $5.60. Confined chiefly to the presentation of various analytical methods for the solution of engineering problems, this text covers equations readily integrable; equations having periodic solutions; the equivalent linear equation; equations having periodic coefficients; the method of slowly varying amplitude and phases; and graphical and numerical solutions. Among the new topics treated in this edition are phase trajectories, stability criteria, and fluid flow in two dimensions. References are given to more rigorous theoretical treatments of the methods discussed.

POWER PLANTS. By Alexander H. Zerban and Edwin P. Nye. Second Edition, 1956. International Textbook Company, Scranton, Pa. 655 p., 6 × 9¼ in., bound. $8.50. The new edition of this text previously published under the title "Steam Power Plants," has been broadened in scope to provide a co-ordinated treatment of all types of power-generation equipment. The material on internal-combustion plants has been expanded, a new chapter on hydro plants has been added, and recent developments such as supercritical vapor cycles and nuclear power are discussed.

POWER SYSTEM STABILITY. Volume 3. Synchronous Machines. By Edward Wilson Kimbark. 1956, John Wiley and Sons, Inc., New York, N. Y. 322 p., 5⅞ × 9¼ in., bound. $10. The final volume of a work intended for power-system engineers and graduate students. Devoted to the theory of synchronous machines and their excitation systems, the book deals with such major topics as reactances, resistances, time constants, short circuits, saturation, damping, and damper windings. Steady-state stability, briefly treated in the first volume, is discussed fully in the present volume.

PROGRESS IN NUCLEAR ENERGY. Series 4. Technology and Engineering. Volume 1. Edited by R. Hurst and S. McLain. 1956,

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McGraw-Hill Book Company, N. Y., N. Y. 420 p., $6^1/_4 \times 9^1/_4$ in., bound. $12. Comprised of selected papers by a number of authorities, this volume reviews the present state of knowledge on coolants, moderators, heat transfer, reactor chemistry, and reactor corrosion. Included are papers dealing with the production of heavy water, graphite, and beryllium oxide; liquid-metal handling and pumping; pumps for cooling systems; heat transfer in boiling water systems; and aqueous corrosion of zirconium.

PROPERTIES OF COMBUSTION GASES/SYSTEM: C_nH_{2n} - Air. Volume 1. Thermodynamic Properties. Volume 2. Chemical Composition of Equilibrium Mixtures. Compiled by the AGT Development Department, General Electric Company. 1955, McGraw-Hill Book Company, New York, N. Y. 377 p., 677 p., $8^5/_8 \times 10^7/_8$ in., bound. $75 (2 volumes). Comprehensive tables of data on the properties and behavior of the working fluid of the air-breathing combustion engine, at temperatures from 600° to 5000° R and pressures of 0.01 to 30 atm. Applicable to the combustion gases of any hydrocarbon fuel with a hydrogen to carbon atom ratio of two, the data are intended for use by engineers engaged in combustion research, gas-turbine and turbojet engine development, aircraft and missile propulsion, etc. Both volumes contain explanatory introductions, that of volume one including several worked-out examples of applications of the tables.

ROCKET PROPULSION ELEMENTS. By George P. Sutton. Second Edition, 1956. John Wiley and Sons, Inc., New York, N. Y. 483 p., $5^1/_2 \times 8^5/_8$ in., bound. $10.25. Designed as a reference manual and college text, this book deals with both liquid and solid propellant rockets, their fuels, physical mechanisms, and design. It also includes material applicable to both types: general principles of thermodynamics, heat transfer, flight theory, testing methods, and historical background. There is a bibliography of over 600 references.

SCIENCE AND ECONOMIC DEVELOPMENT. New Patterns of Living. By R. L. Meier. 1956, John Wiley and Sons, Inc., New York, N. Y. 266 p., $5^7/_8 \times 9^1/_4$ in., bound. $6. The author briefly reviews world needs and resources and discusses possible means of attaining a reasonable level of living for the world's population by the application of recent discoveries in science and technology, particularly in the areas of foods and fuels. He also deals with the possible effects of new technologies on social and industrial organization, and suggests that a "mutant type of scientist and engineer," a scientist-executive, may achieve dominance in the resulting society. Fundamental problems needing solution—the protein supply, low-grade ore utilization, means of transport, and others—are listed in an appendix.

STEEL FOUNDRY DUST CONTROL AND VENTILATION. Report of a Conference, October, 1955. 1956, British Steel Castings Research Association, Sheffield, England. 98 p., $7^7/_8 \times 9^7/_8$ in., papers. 42s. The technical papers included in this publication deal with the control of dust from grinding machines and at foundry knock-outs; dust extraction at the pneumatic chisel; a low volume, high velocity exhaust system; sampling airborne dust; the efficiency of dust collectors; and foundry heating and ventilation.

SYMPOSIUM ON IMPACT TESTING. (ASTM Special Technical Publication No. 176.) 1956, American Society for Testing Materials, Philadelphia, Penna. 169 p., 6×9 in., paper. $3.50. In addition to a number of papers on notched bar testing, this symposium includes papers on shock tests that deal with tests for parts, components, and complete structures. Typical subjects dealt with are testing from room temperature to −236 C; longitudinal impact tests of long bars with a slingshot machine; a shock tester for shipping containers; and properties of concrete at high rates of loading. The impact tube is discussed in one of the papers.

SYMPOSIUM ON POWDER METALLURGY. (London, December, 1954.) 1956, The Iron and Steel Institute, London. (Special Report No. 58.) 390 p., $8^3/_8 \times 11^1/_8$ in., bound. 65s. The 50 papers included in this volume are presented in four groups covering the manufacture, properties, and testing of powers; the principles and color of compacting and sintering; the manufacture and properties of structural engineering components, and the powder metallurgy of high-melting-point materials. Some of the papers, such as those on manufacturing methods, the powder metallurgy of zirconium, and powders for magnetic applications, are review papers; others deal with specific processes or materials: testing of ceramal materials, porous stainless steel, hot compacting, etc.

LES TRANSMISSIONS DE PUISSANCE. By Pierre Patin. 1956, Editions Eyrolles, Paris, France. 338 p., $6^1/_4 \times 9^3/_4$ in., bound. Fr. Frs. 3300. A comprehensive treatment of power-transmission methods, including speed changing devices. Part 1 covers theoretical considerations of power transmission, some discussion of strength of materials, and more detailed treatments of the principles of operation of many types of power transmissions for a wide range of uses. Part 2 gives descriptions of specific devices and machines. Brief treatments are included of bearings, pump units, and servomechanisms.

VDI—STEAM TABLES. Sponsored by Verein Deutscher Ingenieure, 4th edition edited by E. Schmidt. 1956, Springer-Verlag, Berlin, Germany. 109 p., $8 \times 11^5/_8$ in., boards. DM 15.00. In this new edition the temperature range has been extended to 800 C with a pressure range to 300 atm. The three sections of the tables are as follows: state of saturation (temperature table); state of saturation (pressure table); values of volume, enthalpy, and entropy for water and superheated steam. The large, folded Mollier diagram is in a pocket at the back. The foreword and the explanatory introduction are given in three languages, German, English, and French.

THE ULTIMATE-LOAD THEORY APPLIED TO THE DESIGN OF REINFORCED AND PRESTRESSED CONCRETE FRAMES. By A. L. L. Baker. 1956, Concrete Publications, Ltd., London, England. 91 p., $5^7/_8 \times 9^1/_4$ in., bound. $4. This is an exposition of a design method based on the assumption of plastic hinges in frames, developed at the Imperial College of Science and Technology in London. The following topics are treated: ultimate strength in bending of beams; plastic deformations of hinges and members; the theory of plastic hinges and the ultimate strength of frames; general expressions for rotations of plastic hinges; and general analysis of four-bay frames. Examples of application of the plastic hinge theory in the design of continuous beams and building frames are given in the last chapter.

THE UPPER ATMOSPHERE. By S. K. Mitra. Second Edition, 1952. The Asiatic Society, Calcutta, India. 713 p., $6^1/_2 \times 10$ in., bound. 48 Rupees. This comprehensive account of the present state of knowledge of the upper atmosphere covers a wide range of subjects of interest to engineers in the fields of rockets, radio, and aeronautics, as well as to meteorologists and other specialists. Concerned with regions more than 30 miles above the surface of the earth, the book deals with composition, temperature, density, tides, electrical currents, magnetic storms, lights from the night sky, meteoric phenomena, and auroras. One section is devoted to applications of ionospheric data to radio transmission, and the last chapter discusses rocket exploration of the atmosphere. There is a bibliography.

VERÖFFENTLICHUNGEN ZUR ERFORSCHUNG DER DRUCKSTOSSPROBLEME. Volume 2. Edited by F. Tolke. 1956, Springer-Verlag, Berlin. 149 p., $7^1/_2 \times 10^5/_8$ in., paper. DM 37.50. This second group of papers on water hammer deals with several investigations of problems and design considerations in hydroelectric plants (4 papers), and with water shock in household water pipes (1 paper). The detailed analyses are illustrated by many graphs and diagrams for effective interpretation.

WARMFESTE UND KORROSIONSBESTÄNDIGE SINTERWERKSTOFFE. (Proceedings of the Second Plansee Seminar, 1955.) Edited by F. Benesovsky. 1956, Springer-Verlag, Wien, Austria. 472 p., $6 \times 9^1/_4$ in., bound. $10.30. An edition with English summaries of the foreign language papers is available from Pergamon Press, Inc., New York, N. Y. $12.50. The 38 papers presented at this seminar deal with a wide range of topics concerning carbides and other very hard materials: physico-chemical and metallurgical aspects; characteristics and properties of various metallic and ceramic materials; specific applications of hard materials, including the role of powder metallurgy in the design of nuclear-power reactors; and miscellaneous papers on sintering problems and other aspects of powder metallurgy. Papers are in German or English.

YEAR BOOK OF THE HEATING AND VENTILATING INDUSTRY, 1956. Published 1956 by Technitrade Journals Ltd., London, England. 398 p., $5^2/_8 \times 8^2/_8$ in., bound. 10s 6d. Oil-firing practice, oil-fired air heaters, panel heating, and electric-surface heating of fuel-oil lines and storage tanks are discussed in the four papers included in this manual of technical and trade information for engineers and contractors. The remainder of the volume consists of a 25-page annotated bibliography of the British literature published in 1955, a buyers' guide, information on standards and contracts, and a directory of the society.

Roundup

Of Current Engineering Events, News, and Comment

E. S. Newman, *News Editor*

View of audience at panel on "The Economic Status of the Engineer," held during Engineers Joint Council General Assembly, Jan. 17–18, 1957, at Hotel Statler, New York, N. Y.

EJC Third Annual General Assembly in New York Reviews Engineers' Position in Society

Three panels discuss engineers in government, on the international scene, and their economic status

THREE HUNDRED engineers and scientists attended the third annual Engineers Joint Council General Assembly on January 17 and 18 at the Hotel Statler, New York, N. Y. The two-day meeting heard three panels discuss "The Problem of the Engineer in Government Service," "The Impact of the Engineer in International Relations," and "The Economic Status of the Engineer."

Included in the meeting were: A Thursday luncheon at which John Bell Rae spoke on "The Engineer and the American Economy"; the Unity Dinner on Thursday, with Henry T. Heald, Mem. ASME, president of the Ford Foundation, as speaker; and a Friday luncheon at which W. A. B. Iliff, vice-president of the World Bank, delivered a talk on "Overseas Development, Engineers and the World Bank."

Engineers in Government Service

Philip Young, Chairman, U. S. Civil Service Commission and Adviser on Personnel Management to President Eisenhower, opened the first panel with a discussion of the problems of "The Engineer in Government Service." He cited the Federal Government as the largest single employer of engineers and scientists in the United States. With the demand for engineers far exceeding the supply, two major problems are recruitment and utilization. Similarly, the two chief concerns of the engineer are the selection of an employer and development of a useful and satisfying career.

The efforts of the Federal Government to clearly identify its problems and to suggest a course of action were discussed with specific reference to the White House Committee on Engineers and Scientists for Federal Government Programs. This Committee's primary objective is to investigate the personnel management of engineers and scientists by the Federal Government and to develop methods by which this management can be improved.

Pay and utilization were considered to be of primary interest by the Committee. In the area of pay, greater flexibility in the grade-and-salary structure of the Federal Government was considered a major need. Maximum utilization of manpower depends largely upon good personnel management, requiring advance planning of personnel programs, careful and individualized placement, development, and use of employees to their fullest potential, and continuing attention to employee attitudes and morale.

In conclusion, Mr. Young noted that "The primary force that holds our best engineers and scientists in the Federal service is the nature of the work itself, which can inspire a high degree of devotion. To the professional man who feels this sense of dedication, all other considerations, including the financial, are secondary."

The question of engineers in research

and development projects with the Army was discussed by Major General J. B. Medaris and E. Stuhlinger of the Army Ballistic Missile Agency, Huntsville, Ala. General Medaris cited the 100 per cent increase in the number of engineers since 1940 and warned that this is not enough, because the ratio of engineers to all other workers has risen sharply. He called for increased technical training and greater recognition of technical achievement in the high schools. Young engineers were told that they should not expect immunity from the draft. He said, "Our society does not recognize privileges accruing from birth, wealth, political affiliation, or intellectual attainment."

Guided-Missile Engineer

Dr. Stuhlinger discussed the problems of the guided-missile engineer, a classification yet undefined. The close relation of guided-missile engineering to research was noted as its one characteristic feature. The necessity for expanding the frontiers of scientific knowledge and the dependence of guided-missile engineers upon basic concepts of astronomy, solar power converters, electronics, radar techniques, optics, spectroscopy, electrical, and mechanical engineering were stated as significant.

The need for instilling in our youth a "desire to know" and an interest in the basic elements of the natural sciences was also expressed.

The final speaker on the panel was Dwight H. Bray, State Highway Engineer, Kentucky State Highway Department. Mr. Bray spoke of "The State Highway Engineer." He discussed the shortage of engineers, brought about partly as a result of the over-all shortage and partly as a result of disadvantages attached to employment by the state government. He listed the following disadvantages as either "real or imagined": low pay and difficulty of getting quick and adequate salary increases; slow promotion in title and responsibility; lack of in-service training courses; lack of glamour of the work; lack of adequate retirement plan; lack of adequate merit systems.

Accompanying the shortage of engineers is the need for maximum use of the inadequate engineering forces. In this connection, certain states are giving special training courses, allowing overtime pay, and adopting new laborsaving methods; in addition, they are more and more employing the services of consulting engineering services.

Expressed also was the need for making the public aware of the problems and achievement of the professional engineer, in order that the engineer might gain public acceptance and support for his professional aims.

Engineers and American Economy

Those in attendance at the Wednesday luncheon heard John Bell Rae, associate professor of history, Massachusetts Institute of Technology, currently exchange professor of social studies, Case Institute of Technology. Mr. Rae discussed "The Engineer and the American Economy." He noted that men who have had technical skill have normally been the most valuable members of society.

The essential ingredient of our economic and technological achievement, he stated, is freedom. As a result of allowing ability to find its own outlets, the highest standard of living and widest distribution of goods in the history of mankind have been experienced. Mr. Rae sees the preservation and extension of this system as the great objective for which our technologists should be organized and directed. The engineer's contribution to this cause lies first in the realm of production. "The ability of the engineer to harness the forces of nature is a talent given by God to be used for the benefit of mankind." Second, the engineer must assume a substantial share of the responsibility for the management of industry.

Engineer's Economic Status

The Thursday afternoon panel discussed the trends in the earnings of engineers and the principal aids to salary administration.

Drawing on the data provided in the EJC report, "Professional Income of Engineers—1956," Edward B. Peck of Rutgers University emphasized that engineers' salaries have not kept up with national productivity and wages. Probably most upper middle-class wages have reacted in much the same way. There are, however, no sound data comparable to that of Engineers Joint

J. B. Rae of M.I.T. speaks to EJC General Assembly luncheon audience on "The Engineer and the American Economy," on opening day of the two-day program designed to promote the dissemination of information about engineers and their profession

Henry T. Heald, president, Ford Foundation, addressing Unity Dinner audience on the re-evaluation of the engineer in our society. The dinner was highlight event of the third EJC General Assembly held at the Hotel Statler, Jan. 17–18, in New York City.

W. A. B. Iliff, vice-president, International Bank for Reconstruction and Development, Washington, D. C., discusses "Overseas Development, Engineers, and the World Bank" at the Friday, closing day, luncheon of the EJC General Assembly

Council, except that of the American Chemical Society.

This condition, he said, is largely attributed to the attitudes on salaries that prevailed up to about 1952. Salary and wage increases were related to cost of living and cents per hour rather than a percentage increase. Since 1952 the percentage principle seems to prevail.

Professor Peck pointed out that another factor in holding down older engineers' salaries was the failure to separate general raises from • merit and promotional raises.

It is proposed, he noted, that salary administration recognize and take account of three independent factors. First is the secular trend or general increase that is granted to all without regard to individual experience or merit. Second is experience, which must be taken account of throughout the whole career. Third, there should be re-established a merit differential that has real incentive value.

A pattern for pricing different degrees of experience and merit is proposed, according to Professor Peck. It is reduced to formulas that start salary policies and provide flexibility for changes due to the secular trend.

(Excerpts from Professor Peck's paper appear in "Junior Forum" of this issue of MECHANICAL ENGINEERING—Editor)

Position evaluation as an aid to salary administration, it was pointed out by Donald P. Krotz, assistant to the president of California Research Corporation, is a systematic analysis of individual assignments, recording results in position descriptions, comparison both horizontally and vertically with other assignments, placement on a grading ladder, correlation with placements throughout the organization, recognition of outside competition, and a continuing review to assure that placement is on a current basis.

Position evaluation, he continued, is a tool which permits free two-way communication between the employee and his supervisor, and up and down the supervisory chain of command. It makes it practicable for management to recognize relative value received from an individual's performance in terms of the actual assignment, the professional competence of the employee, and his professional potential.

A basis for co-ordinating management judgment is also provided by position evaluation, Mr. Krotz noted, and, with appropriate delegation of authority, permits optimum freedom for supervisors in utilizing the full capacity of their men. It also provides the opportunity for greater internal consistency in using the professional talents available.

The auditing function, Mr. Krotz concluded, provides guidance in comparison with other internal and external factors not readily available to the immediate supervisors. This function also provides a check on the possibility of individual supervisors' being either too lenient or too stringent in their evaluation.

How merit rating can be a practical aid to salary administration for engineers and scientists was discussed by Frank Leamer, personnel director, Bell Telephone Laboratories, Inc.

Actually, he said, there is no one best technique clearly superior to all others for evaluating relative worth of professional technical personnel. It is possible, however, to evaluate relative worth by means of quantitative multiple judgments of relative over-all contribution or performance.

He emphasized that a systematic approach to ranking individuals primarily according to their contributions on their present jobs, taking into consideration potentiality in the case of younger members, is a method of arriving at rate of pay superior to the older instrumentality of "laudation and lung power" or "squeaking wheel gets greased," philosophy often used by appreciative supervisors seeking to obtain increases for their people.

Performance ratings, Mr. Leamer pointed out, should be separated from salary adjustment. Questions of dollars should be emancipated from judgments of performance insofar as possible. Each individual's performance rating should be independent of a prior rating and should be made without reference to present salary position.

Much work is yet to be done on learning how best to merge one performance rank-order list of individuals with another such list made by different raters.

Relation performance ratings to appropriate salary position, he noted, is a gradual and somewhat arbitrary judgmental process that is aided by having a family of salary guide curves which are designed to divide the technical population into proportional parts (octiles, quartiles, etc.) at levels established as a part of salary administration policy.

Performance ratings, Mr. Leamer declared, in addition to providing a sound basis for rate review consideration, also require that supervisors improve their competence in appraising the contributions and characteristics of individuals. Such evaluations provide information that is useful to supervisors in developing greater effectiveness of their associates.

Donald S. Bridgman, former director of college relations, American Telephone and Telegraph Company, acted as moderator for the panel.

Unity Dinner

"Our real problem in engineering is to produce an adequate supply of high-quality people and utilize them properly, stated Henry T. Heald, Mem. ASME, at the EJC Unity Dinner on Thursday evening.

Dr. Heald, president of the Ford Foundation, discussing the re-evaluation of engineering in our society, defined "adequate supply" as the largest number of engineers we can create quickly, but a variable number determined by factors which are themselves variable with time, place, and the ever-changing needs of our economy, and of society.

"Neither the shortage at home nor the increased output abroad are reasons for futile fright," said Dr. Heald. Commenting further on William Benton's report of a 1300 per cent increase in Soviet Union output of engineers, he said, "We ought to be concerned about engineering numbers and quality regardless of what Russia does. We can hope that other countries, too, will improve engineering education, for the emerging, independent, underdeveloped countries of the world need all the engineers they can get.

Of engineering today he said, "Its subdivision and off-shoots are active everywhere, from planning, production and distribution to highly creative innovation and research."

Further he stated, "Engineering in its diversity has become somewhat like medicine; that is, the majority of its practitioners work with the knowledge and use the techniques developed by others. Relatively few engineers are in the research laboratories working on fundamentals, developing new principles, testing new concepts, solving perplexing basic problems, defining new ones."

He pointed out that today's scientist-engineer must be a broad, liberally educated person, capable of examining and evaluating the proportions of society as well as the riddles of nature, of providing the leadership of ideas without which there is no meaningful progress.

"Scientists and engineers," he added, "no less than doctors, lawyers, or the managers of industrial enterprise, need to stand as intelligent, liberally educated men, regarding their knowledge not as a narrow, isolated specialty but as a

particularized competence which they, in their general wisdom, can share with the rest of society.

"The permanent strength of engineering," he concluded, "lies in its ability to respond to man's hope for a better life. People all over the world, who for generations have lived in poverty and degradation, are crying for technical enlightenment by which they can lift themselves from misery, realize their dignity as men, and by so doing, add also to their spiritual stature."

Morris D. Hooven, outgoing president of EJC, acted as toastmaster at the dinner. J. W. Barker, past-president of ASME, was introduced as incoming EJC president.

International Relations

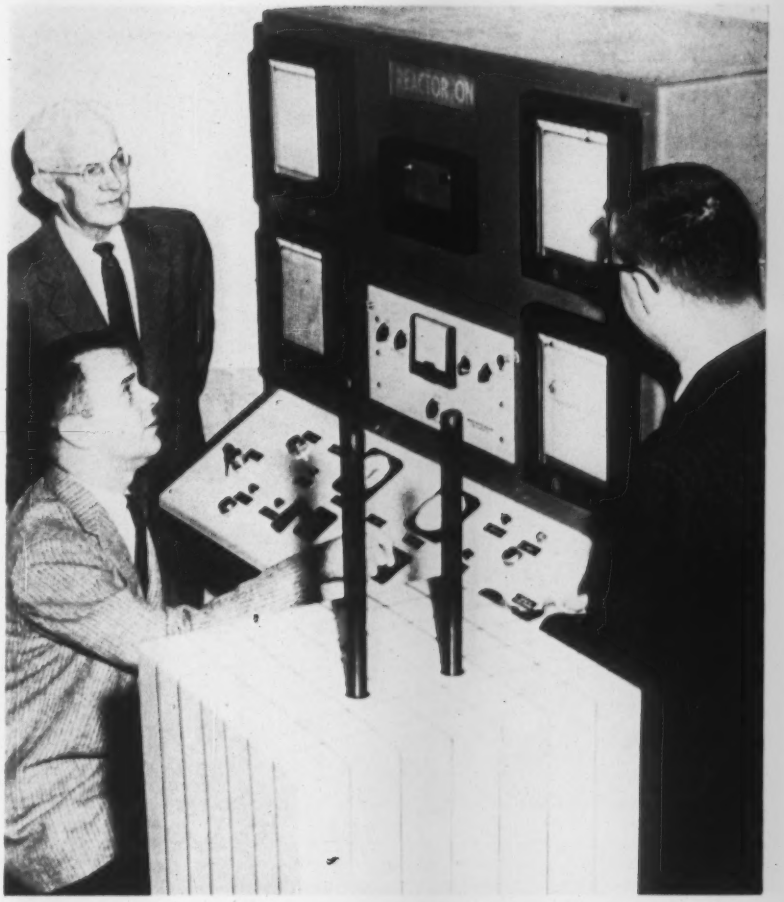
Gail A. Hathaway of the U. S. Army Corps of Engineers was chairman of a panel discussion at the Friday morning session on "The Impact of the Engineer in International Relations." The panel was composed of Carl W. Flesher, director, Office of Industrial Resources, International Co-operation Administration; James T. Duce, vice-president, Arabian American Oil Company; and C. P. Dunn, president, International Engineering Company, Inc.

Mr. Flesher spoke of the part engineers will play in raising standards of living to create new purchasing power, and the ICA's work in encouraging private enterprise to take its valuable know-how into newly developing countries.

Mr. Duce emphasized that although the whole physical world is the engineer's world, political complications hedge him about, and the present multiplication of small nations is increasing the difficulties under which the engineer operates. The best physical solution has to be tailored to the political framework in which it will operate, and the engineer frequently has to assume the role of diplomat.

Mr. Dunn commented on the offensiveness of the terms underprivileged and underdeveloped and the resentment of what has come to be called "great American know how," as well as American salary scales. One foreign official told him, "We know you are teaching our people to live well, but don't do it with our money."

The necessity for the engineer to assume the role of teacher in a country like prewar China with only 14 technicians to 500 million people is obvious. Mr. Duce stated that Aramco has been particularly successful in this respect. Company-trained Bedouin tribesmen often start their own businesses, and one trainee has become several times a millionaire.



The nation's first nuclear reactor simulator for training and research is shown in operation at the Virginia Polytechnic Institute atomic energy laboratory. John W. Whittemore, *upper left,* dean of engineering and architecture, and Thomas M. Hahn, Jr., *right,* head of physics and nuclear engineering physics, observe as a graduate engineer operates controls. The simulator, developed by Leeds and Northrup Company, Philadelphia, Pa., consists of a control console, an electronic analog computer, and a model of a reactor core, *foreground.* By imitating precisely the behavior of an actual reactor, the simulator provides necessary experience in the operation of various type reactors. Simulators are expected to assume increasing importance in the over-all educational and training program to reduce the critical shortage of trained nuclear scientists and engineers.

Development, Engineers, and World Bank

W. A. B. Iliff, vice-president of the International Bank for Reconstruction and Development, was the luncheon speaker. In explaining that "engineering skills and banking techniques have come to depend more and more upon one another," he stated that although the World Bank has no part in the contractor's selection of engineers, the Bank is interested in the quality of the engineering know-how and design that goes into the research and development of a project.

World Bank analyses of potential projects range "all the way from the very general to the very specific." The Bank must determine if the project is the best solution to a particular problem and its relation to the country's economy. Would hydro or thermal power, rail or highway transportation be preferable? Is the project too ambitious? "Is the country cutting off its agricultural nose to save its industrial face?"

He concluded that finding ways to meet the challenge which the economic growth of these countries represents "is one of the most difficult tasks western leaders have ever faced."

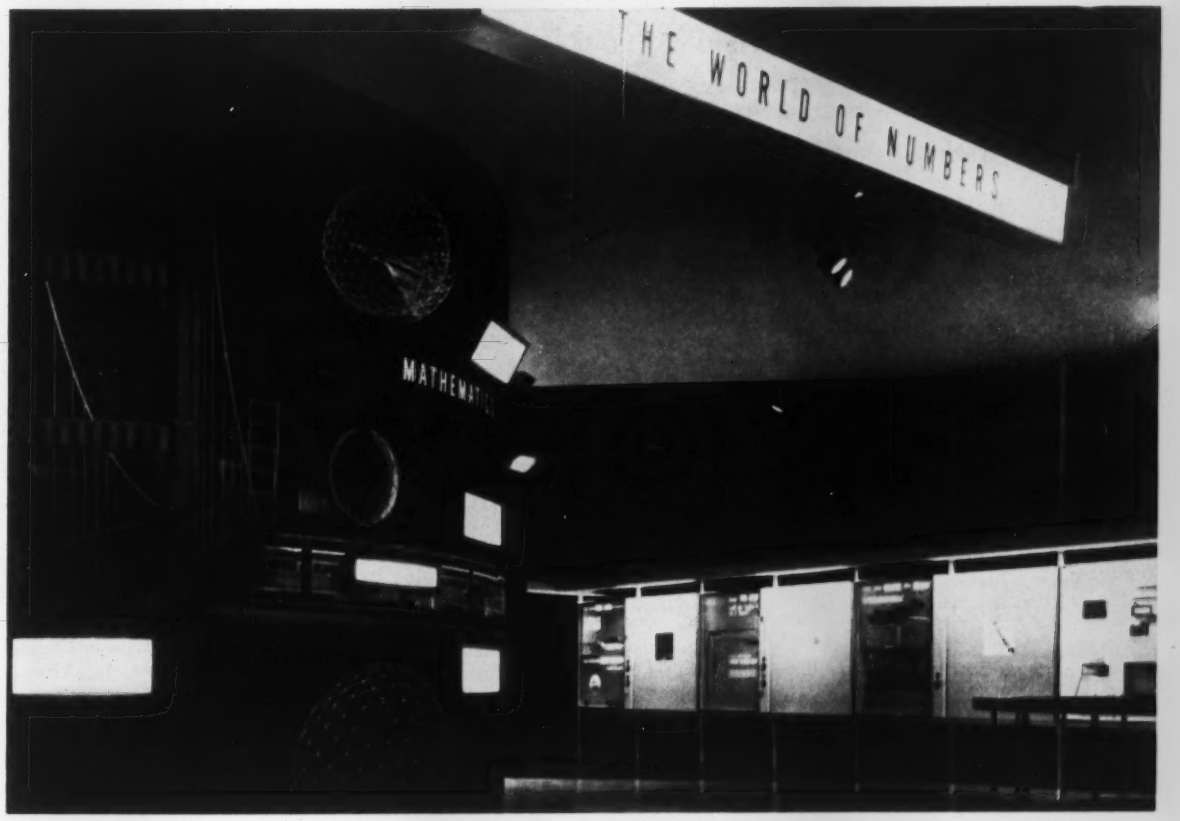
Viewing the supervisory control of Univac, *left to right,* are L. R. Groves, vice-president, Sperry Rand; S. Wyman Rolph, president, The Franklin Institute; Howard Aiken, professor of applied mathematics, Harvard University, and principal speaker at opening of the Univac Computing Center and a permanent exhibit at the Institute showing "The Progress of Computation," Jan. 22, 1957. Dr. Aiken said that "man is not obsolete"; however great these machines are, they are but the tools of man. From the earliest gropings of man to develop power, instruments, and tools to a combination of all of these to produce consumer goods, not one of these tools has ever been known to have one "idea."

Man Counts . . .

. . . Fingers to Computers

Fountainhead, sculpture by Seymour Lipton, symbolizing human brain at work

Left to right: A. C. Carlton, director of the Museum of The Franklin Institute; J. S. Burlew, executive vice-president of the Institute; Howard Aiken, professor of applied mathematics, Harvard University; Lieut. Gen. L. R. Groves, vice-president, Remington Rand; S. Wyman Rolph, president of the Institute; and the operator of the supervisory control of Univac watch an operation of the computer. Univac augments the service rendered in the field of computation by The Franklin Institute which already has in service the analog computer and the A-C Network Calculator.



Gateway to the International Business Machines exhibit "World of Numbers," at the Museum of Science and Industry, which recently was opened to the public in Chicago, Ill. The exhibit employs more than 24 newly created, colorful displays to show the vital significance of mathematics in our modern world and the many rewarding careers open to mathematicians.

Above: T. J. Watson, Jr., *left,* president of IBM, and Major L. R. Lohr, president of the Museum of Science and Industry, at exhibit of various types of memory devices in the "World of Numbers," IBM's exhibit at the museum. By dramatizing the fascinating and active part of numbers in our ordinary daily lives as well as in complex business and scientific operations, the displays encourage the study of mathematics as a means of economic and technological progress for both the individual and the nation.

Below: Dr. M. A. Woodbury, research professor of mathematics at New York University, reads a number from a display panel of the IBM 650 medium-sized "mechanical brain" that went into operation recently at the NYU College of Engineering. The $250,000 electronic computer is the first of its type to be placed in an educational institution in the New York area under a program whereby IBM contributes 60 per cent of the $4000 monthly rental fee.

Meetings of Other Societies

March 14–15
IAS, flight propulsion meeting, Carter Hotel, Cleveland, Ohio

March 20–22
SAE, national production meeting and forum, Hotel Statler, Buffalo, N. Y.

March 23–28
American Society of Tool Engineers, 25th annual meeting, Shamrock Hotel, Houston, Texas

April 1–4
American Association of Petroleum Geologists, Kiel Auditorium, St. Louis, Mo.

April 3–5
American Rocket Society, spring meeting, Sheraton Park Hotel, Washington, D. C.

April 8–10
American Institute of Mining, Metallurgical and Petroleum Engineers, open hearth and blast furnace conference, Hotel William Penn, Pittsburgh, Pa.

April 8–12
American Welding Society, annual national meeting and welding show with AIEE conference, Sheraton, Bellevue-Stratford and Benjamin Franklin Hotels, Philadelphia, Pa.

April 15–17
American Society of Lubrication Engineers, annual meeting and exhibition, Sheraton-Cadillac Hotel, Detroit, Mich.

(For ASME Coming Events, see page 319)

People

Honors and Awards. Two former deans of the College of Engineering and Architecture at the Pennsylvania State University have been honored with the naming of two campus buildings. Main Engineering Building, constructed in 1929, has been designated Sackett Building, honoring the late ROBERT L. SACKETT, Mem. ASME, while an engineering building to be constructed by the General State Authority, will be known as Hammond Building, honoring the late HARRY P. HAMMOND, Mem. ASME.

HARRY F. GUGGENHEIM, senior partner of Guggenheim Brothers, and AIR COMMODORE F. RODWELL BANKS, director of the Bristol Aeroplane Company, Ltd., were named 1956 Honorary Fellows of the Institute of the Aeronautical Sciences. The honor is the highest that the Institute can bestow. Formal presentation was made at the IAS 25th annual meeting honors night dinner, January 28, in New York, N. Y. Also honored at the dinner were: ROSS GUNN, director of physical research, U. S. Weather Bureau, Robert M. Losey Award; C. L. JOHNSON, vice-president—engineering and research, Lockheed Aircraft Corporation, Sylvanus A. Reed Award; G. F. JUDE, director, Flight Control Engineering, Sperry Gyroscope Company, Lawrence A. Sperry Award; and Ross MCFARLAND, associate professor of industrial hygiene, Harvard University, John J. Jeffries Award.

CLAUDE E. SHANNON, mathematician, was the recipient of the 1956 Research Corporation Award. The award acknowledged his work on information theory, the basis of electronic computing machines, and his work on the theory of complex machines, the basis for the design of machines that control other machines. The award, consisting of $2500, a plaque, and a citation was presented by J. W. BARKER, past-president and Mem. ASME. Dr. Shannon, visiting professor of electrical communications at the Massachusetts Institute of Technology since January, 1956, has been a mathematical consultant to the research department of Bell Telephone Laboratories since 1941.

New Officers. WALTER J. BARRETT, New Jersey Bell Telephone Company engineer, was nominated to be 1957–1958 president of the American Institute of Electrical Engineers at the AIEE winter general meeting. EDWARD H. ANSON, senior vice-president and director, Gibbs & Hill, Inc., New York, N. Y., has been elected president of the American Institute of Consulting Engineers.

PETER SIMMONS of the Dow Chemical Company was recently elected president of the Society of Plastics Engineers.

Campus Appointments. ERNST WEBER has been appointed vice-president for research at the Polytechnic Institute of Brooklyn. Harry S. Rogers, Mem. ASME, president of the Institute, on announcing the appointment also said that the newly created post has been made necessary by the growth of research projects. These now represent annual expenditures of more than $2,250,000 at the Institute, he said.

NICHOLAS J. HOFF, Mem. ASME, leading researcher in aeronautical structures, has been appointed to the Stanford University faculty. Presently professor and head of the aeronautical-engineering department of Polytechnic Institute of Brooklyn, he is past-chairman of the ASME Applied Mechanics Division. His Stanford appointment will be effective with the start of the academic year, Sept. 1, 1957.

Results of U. S. Government Research Available to Science and Industry

NONCLASSIFIED results of the growing volume of Government-financed scientific research, estimated at a $2.7 billion level for the current fiscal year, are being turned over to American science and industry in increasing quantity through the Office of Technical Services, U. S. Department of Commerce.

Government research represents about half of the total research and development work of the nation, and many of the developments achieved through this research have immediate application in industrial plants and scientific laboratories. For this reason, OTS, operating under a special law passed by Congress in 1950, is responsible for collecting research reports from the Army, Navy, Air Force, Atomic Energy Commission, and other agencies, reproducing them, and selling them to the public at the cost of reproduction and handling. Last year approximately 182,000 printed or microfilmed copies of such reports were sold.

In addition to research reports, OTS also publishes abstracts of Government-owned patents that are now free for use by private firms on a nonexclusive basis.

To keep science and industry advised of new material released through OTS, the office issues news releases to the trade, business, and technical press and publishes two monthly periodicals. *U. S. Government Research Reports*, a bibliography, describes 300 to 600 new reports in each issue. *Technical Reports Newsletter* reviews 15 to 20 of the most widely useable reports collected by OTS each month. These publications may be ordered from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at $6 a year for the USGRR and $1 a year for *Technical Reports Newsletter*. In addition, subject catalogs have been prepared in some fields, and a list of these *Catalogs of Technical Reports* is available from OTS.

The quantity of material available from OTS has increased rapidly in recent years, both because of expanded acquisition efforts and because of the increasing volume of Government research to meet new technical requirements for the nation's welfare.

ASME News

With Notes on Society Activities and Events

E. S. Newman, *News Editor*

Birmingham Section Host to 1957 ASME Spring Meeting, April 5–10

Student and Regional Administrative Meetings, technical sessions, and inspection trips included in full program

The Birmingham Section of The American Society of Mechanical Engineers will be host during six days of ASME activity beginning with the Region IV Student Conference on April 5 and followed by the Region IV Regional Administrative Conference and the 1957 Spring Meeting of the Society. All three meetings will take place in the Dinkler-Tutwiler Hotel, Birmingham, Ala.

Vulcan, the deity of the forge, looks down from his pinnacle 180 feet above Red Mountain overlooking the prosperous valleys of the Birmingham area, and must be proud of the industry he sees there. He represents the wealth of iron ore to be found in the Birmingham hills. His name is part of many a commercial enterprise.

Vulcan of mythology was no handsome Greek god; he was rather a squat, powerful, malformed dwarf, whose massive shoulders and arms came from long hours at the forge, and was so sculptured by G. Moretti, the famed Italian sculptor.

Student Conference

Two hundred and fifty students are expected to attend the Student Conference at which papers will be presented by speakers representing the thirteen student sections of the Region. After the presentation of papers Friday morning, two inspection trips are planned for the afternoon. One will be to the Norris yards of the Southern Railroad where the latest principles of remote controlled freight-car and train handling will be demonstrated, and a second trip will consist of plant visitations to the Chicago Bridge and Iron Company and the American Cast Iron Pipe Company. Friday's activities will conclude with a student dance at the Dinkler-Tutwiler.

Regional Administrative Conference

On Saturday, the presentation of student papers will continue and the Regional Administrative Conference will convene. The day's activities will be highlighted by the Joint RAC-Student banquet at which ASME President W. F. Ryan will speak. The student-paper winner will be honored at this time.

On Sunday, April 7, the Regional Administrative Conference will continue throughout the day. Registration for the Spring Meeting will commence Sunday afternoon and will be followed by a get-acquainted social gathering sponsored by the Birmingham Section.

Featured Speakers

In addition to the technical sessions to be presented at the Spring Meeting, the feature events include the traditional President's Luncheon on Monday, April 8. President W. F. Ryan will address the luncheon on the subject of "Communications." On Tuesday, April 9, the Power Division will sponsor a luncheon at which Shelton Fisher, publisher of *Power*, will relate some of his experiences on his recent trip to the Soviet Union. The Banquet to be held Tuesday evening will feature James L. Brakefield who will talk on the subject "The Sixth Factor in American Business."

Inspection Trips

An interesting and extensive inspection trip program has been planned by the

Vulcan, mythical god of the forge and symbol of Birmingham, Ala., stands high on a hilltop overlooking the city where the 1957 ASME Spring Meeting will be held, April 7–10, at the Dinkler-Tutwiler Hotel

ASME Tours in 1957

To Puerto Rico—April 10th to 15th & 19th *To Hawaii—June 14th to 24th*

For information giving details of these trips

Address: ASME Headquarters
29 West 39th Street
New York 18, N. Y.

PUERTO RICO—The trip will originate at Birmingham, Ala., following the Spring Meeting of ASME. Those who do not attend that meeting may leave from New York, N. Y., and the return may be made either via Miami, Fla. or New York, N. Y. Provision is made for a brief visit to the Virgin Islands for those who can remain a few more days.

HAWAII—June 14 to 24 or 29, 1957—following the Semi-Annual Meeting at San Francisco, Calif. This trip includes four of the nine Islands, Oahu, Maui, Kauai, and Hawaii. The main party will fly to Hawaii via United Airlines and return via the Matson Steamship "Lurline."

Birmingham Committee. On Monday, a trip will be conducted after the President's Luncheon to the Gorgas Steam Plant of the Alabama Power Company. This plant, located on the Warrior River is interesting from several standpoints. This steam-power plant represents both the old and the new as far as steam-power production is concerned. The plant is located in the Warrior Coal Fields and fuel is transported from the mine to the plant by conveyers. Here also is located the underground coal-gasification project being carried on by the Alabama Power Company in co-operation with the Bureau of Mines. Dinner will be served at Gorgas to the participants as a courtesy of the Alabama Power Company.

The second trip on Monday will be conducted in the evening and will be to the American Cast Iron Pipe Company. ACIPCo is a high-production pipe foundary producing pressure pipe by the sand-lined mold process which was developed by ACIPCo engineers. The night operations are quite spectacular and should be interesting to the women.

Three trips are planned for Tuesday afternoon, April 9. One will be to the Tennessee Coal and Iron Division of U. S. Steel, Fairfield Works, where the complete manufacture of steel from the refining of finished steel products will be observed at close hand. Included in the tour will be blast furnaces, open-hearth furnaces, blooming mills, hot-strip mills, plate mills, structural mills, merchant mills, and the cotton-tie and hoop mills. The steel industry in Birmingham is unique in that iron ore, metallurgical coal, and limestone are all available in the space of a few miles.

A second trip on Tuesday to be offered will be to the Continental Gin Company where the operation of a complete cotton gin equipped with the latest machinery will be demonstrated. The manufacture of automation machinery will also be observed.

A third trip to Hayes Aircraft Company has also been scheduled for Tuesday afternoon. This plant, established primarily as a modification center for the Air Force, has extended its activities to include the complete repair and overhaul of many types of military aircraft, and is engaged in the construction of refueling tankers.

Redstone Arsenal

The Spring Meeting will terminate with an all-day trip to the Redstone Arsenal located in Huntsville, Ala. In addition to the actual inspection of facilities at the Arsenal, those attending will be given a briefing on Army Ballistic Missile Agency and the Ordnance Guided Missile School. The Arsenal's museum will be visited as well as rocket test firing on ballistic track and a display of the Nike and Corporal guided missiles. Luncheon will be served in the Officer's Club at the Arsenal.

In addition to the feature events which will be of interest to the women, a tour of Birmingham is planned for Tuesday, April 9. This tour will include a visit to historic Arlington, an ante bellum home, and will be followed by a luncheon at "The Club" high atop Red Mountain overlooking Birmingham.

Puerto Rico Trip

A trip to Puerto Rico will originate at Birmingham following the Spring Meeting. Those who do not attend the meeting may leave from New York City and join the ASME trip and may return either via Miami or New York. Provision will be made for a brief visit to the Virgin Islands for those who can remain a few more days. Full particulars may be obtained by writing ASME Headquarters, 29 West 39th Street, New York 18, N. Y.

Technical Program

The tentative technical program follows:

MONDAY, APRIL 8

8:00 a.m.

Registration

9:30 a.m.

Production Engineering (I)—Management

Newest Techniques in Managing Maintenance[1]

Component Fatigue Analysis for Maintenance, by *R. J. Laux*, E. I. du Pont de Nemours & Co., Inc. (Paper No. 57—S-12)

9:30 a.m.

Fuels (I)—Power (I)

Station-Design Considerations in Evaluating Selection of Fuels[1]

Pulp and Paper-Mill Trends Toward Integrating Power and Bark-Burning Boilers[1]

9:30 a.m.

Materials Handling (I)

Log Handling in Pulp and Paper Mills[1]

[1] Paper not available—see box below.

Orders for Technical Papers

ONLY copies of *numbered* ASME papers will be available. Some of these papers may not be available in time to permit your receiving them in advance of the meeting. Your order will be mailed only when the complete order can be filled unless you request that all papers available ten days before the meeting be mailed at that time. Please order only by paper *number;* otherwise the order will be returned. The final listing of available technical papers will be found in the issue of MECHANICAL ENGINEERING containing an account of the meeting.

Copies of ASME papers may be obtained by writing to the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Papers are priced at 25 cents each to members; 50 cents to nonmembers. Payment may be made by check, U. S. Postage stamps, free coupons, or coupons which may be purchased from the Society. The coupons in lots of ten, are $2 for members, $4 for nonmembers.

Copies of unnumbered papers, listed in the program, *are not available* because the review of these manuscripts had not been completed when the program went to press. The author's name and paper number will appear with paper title in the final program (final program available only at meeting) as well as in the issue of MECHANICAL ENGINEERING containing an account of the meeting, if the paper has been recommended for publication in pamphlet form.

Registration Schedule

Sunday, April 7, 2:00 p.m. to 5:00 p.m.
Monday, April 8, 8:00 a.m. to 7:30 p.m.
Tuesday, April 9, 8:00 a.m. to 3:00 p.m.
Wednesday, April 10, 8:00 a.m. to 10:00 a.m.

Automated Materials Handling in Appliance Factories[1]

12:15 p.m.

President's Luncheon

Presider: *James H. Sams*, Vice-President, Region IV, Clemson Agricultural College
Speaker: *William F. Ryan*, ASME President
Subject: **Communications**

2:30 p.m.

Education—Junior (I)

Panel Discussion: "Engineering Education for the Modern World"

Nathan W. Dougherty, University of Tennessee and ARO, Inc.
John H. Frye, Jr., Oak Ridge National Laboratory
Eugene Miller, Redstone Arsenal

2:30 p.m.

Materials Handling (II)

Tomorrow is Here Today[1] (Paper to be supplemented by British film, "Conveyers as Your Servants")

Cost Control Can Be the Answer for Materials-Handling Problems[1]

Charts and Graphs That Help Solve Materials-Handling Problems[1]

The Fork-Trucks Place in the Materials-Handling Picture[1]

7:30 p.m.

Junior (II)

Panel Discussion: "What Can the Young Engineer Do to Develop Professionally?"

The Young Engineer's Professional Development in the Training Program of the Large Corporation: *Lonnie B. White, Jr.*, U. S. Steel Corp.

The Young Engineer's Development in a Small Company: *William B. Speir*, Rust Engineering Co.

Can the Technical Societies Help the Young Engineer?: *Erskine Vandegrift, Jr.*, American Cast Iron Pipe Co.

Registering as a Professional Engineer: *Andrew H. Payne, Jr.*, consulting engineer, Birmingham, Ala.

The Engineer's Place in Management: *John W. Little*, Goslin-Birmingham Manufacturing Co., Inc.

TUESDAY, APRIL 9

8:00 a.m.

Registration

9:30 a.m.

Machine Design (I)

A Simple Formula for Determining the Position of Maximum Slider Velocity in a Slider-Crank Mechanism, by *Ching-U Ip* and *L. C. Price*, Michigan State University (Paper No. 57—S-8)

Undercutting of Spur Gear Teeth, by *G. H. Martin*, Michigan State University (Paper No. 57—S-3)

Techniques of Drawing in the Third Dimension, by *David Gordon*, mechanical draftsman, Bridgeport, Conn. (Paper No. 57—S-5)

9:30 a.m.

Power (II)—Fuels (II)

A Practical Approach to the Allocation of Heat in an Industrial Power Plant, by *R. J. Martin*, Beaunit Mills, Inc. (Paper No. 57—S-10)

[1]Paper not available—see box on page 306.

Mathematical Techniques of Incremental Loading[1]

Power in the Paper Industry[1]

Economic Load Allocation Using the "Early Bird" Incremental Cost of Power Delivered Computer[1]

9:30 a.m.

Production Engineering (II)

Production Engineering of Large Liquid-Fuel Rocket Engines, by *K. K. Dannenberg*, Army Ballistic Missile Agency (Paper No. 57—S-11)

Production Engineering of Solid-Fuel Rocket Motors, by *E. C. Roberts, A. L. Couch, Jr.*, and *R. D. Walker*, Redstone Arsenal (Paper No. 57—S-4)

12:15 p.m.

Power Luncheon

Presider: *James M. Todd*, Past President, ASME; Design Engineers Associated, formerly, James M. Todd & Associates
Introduction of Speaker: *E. E. Williams*, Duke Power Co.
Speaker: *Shelton Fisher*, McGraw-Hill Publishing Co.
Subject: **Soviet Power System—1957**

2:30 p.m.

Metals Engineering

The Back Extrusion of Heavy-Walled Zircaloy-2 Cups[1]

True Stress-Strain Properties of Zirconium Alloy[1]

Tests on Aluminum Mock-Ups of Zircaloy Pressure Vessels[1]

2:30 p.m.

Machine Design (II)

Design of Warped Buckets for Optimum Efficiency, by *W. H. Wiebe*, De Laval Steam Turbine Co. (Paper No. 57—S-1)

Development of the Natco Feed Rate Indicator, by *R. A. Schafer* and *V. E. Tice*, National Automatic Tool Co., Inc. (Paper No. 57—S-6)

2:30 p.m.

Heat Transfer—Power (III)

Free Convection From Heated Surfaces—Laminar-Boundary Layers, by *Joseph Rutkowski*, Wayne State University (Paper No. 57—S-7)

A Simplified Method for the Study of Two-Dimensional Transient Heat Flow Using Resistance Paper, by *A. V. Clark*, U. S. Naval Research Laboratory (Paper No. 57—S-9)

Promotion of Dropwise Condensation of Several Pure Organic Vapors, by *R. P. Bobco* and *A. L. Gosman*, Northrop Aircraft, Inc. (Paper No. 57—S-2)

7:00 p.m.

Banquet

Toastmaster: *Stephen D. Moxley*, American Cast Iron Pipe Co., Birmingham, Ala.
Speaker: *J. L. Brakefield*, Liberty National Life Insurance Co., Birmingham, Ala.
Subject: **The Sixth Factor in American Business**

Industry at night in Birmingham, one of the few spots in the world where the basic materials of steelmaking—iron ore, limestone, and coal—are found in abundance in a single area

1957 Technology Executives Conference Convenes at Arden House

Research, Publications, Meetings, and Professional Divisions Problems Aired

THE 1957 ASME Technology Executives Conference got under way at 6:00 p.m., Sunday, January 6, at Arden House, Harriman, N. Y. Before adjournment at 3:00 p.m. January 8, some 75 representatives of various Divisions of the Society took part in a program of lectures, discussions, informal gatherings, and highly-organized "brainstorming" sessions, all designed to acquaint new officers with the technological operations of the Society, and to improve those operations.

Arden House, which housed the conference for the first time, is the 96-room main building of what was once a 30-square mile estate of the Harriman family, located 48 miles north of Manhattan. Some 1500 feet above sea level, it commands a view of the lesser peaks of the Ramapo Mountains. The house was donated to Columbia University in 1950 by W. Averell Harriman, now Governor of the State of New York, and is operated by Columbia for educational programs and conferences.

After a predinner get-together on Sunday evening, members attended a Kodachrome presentation by Robert H. Bacon, 1957 chairman of the Board of Technology, covering his travels in Europe during the 1956 World Power Conference in Vienna and the 100th Anniversary Meeting of Verein deutscher Ingenieure in Dusseldorf.

First item on Monday's agenda, following a call to order by Mr. Bacon and a welcome by ASME President William F. Ryan, was a talk by Allen W. Thorson who reviewed the history of TEC Conferences and outlined the remainder of the program. He also noted the formation of a Technical Development Committee during 1956 whose objective is to survey current and plan future ASME technical activities. He also reported the establishment of a Solar Energy Application Committee which he cited as an example of changes needed to keep up with tcehnical advances.

Research

Following Mr. Thorson, Everett M. Barber, chairman of the Research Executive Committee spoke on current and projected research activities of the Society. Currently, 19 Research Committees, with 675 members spend some $250,000 per year in various fields. Despite some good results, over-all operation is disappointing, Mr. Barber said, which, he added, points up the need for improvement, particularly in the areas of communications and administrative procedures.

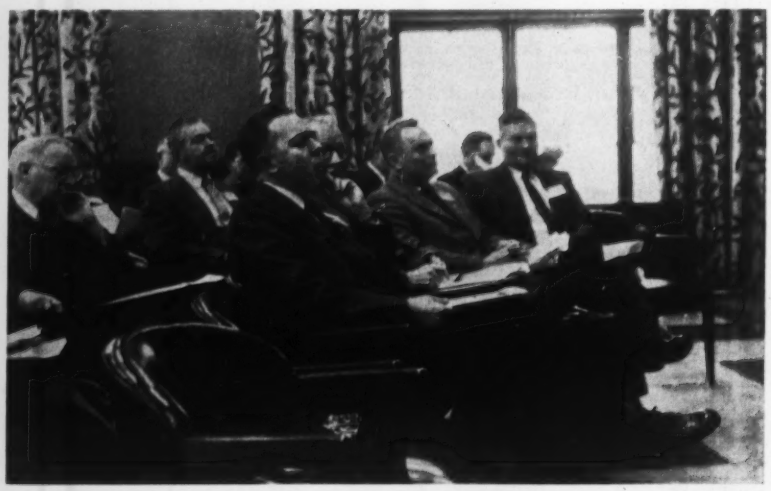
To improve communications he called for an annual report on research in which individual research committees would outline their work and report on progress each year. Copies would be available to the Board on Technology, the Council, and interested ASME members. Supplementing the annual report Mr. Barber proposed regular meetings of the Research Planning Committee at which research committees would review current efforts.

As a step toward clarification of administrative procedures, Mr. Barber proposed preparation of a set of "Rules of Administration" which would be available to all concerned. Need for such a set of rules, available for easy reference, is emphasized by the fact that ASME research activities are administered by committees of volunteers whose membership is subject to turnover.

Other problems discussed by Mr. Barber in his talk and response to ques.ions from the floor include: The need to speed the operation of research committees; establishment of some difference in nomenclature to distinguish between committees actively conducting research projects and those engaged in editing and compiling reports of previous research; the desirability of extending interest in research to the division and section level; and the need for wider recognition of the advantages which ASME sponsorship of research can bring.

Publications

A review of the activities and problems of the Publications Committee by William E. Reaser centered on procedures for reviewing and publishing papers and the influence of these procedures on establishment of deadline dates. There was further discussion of need for coordinating publications and meeting activities including efforts to encourage Divisions to sponsor joint technical ses-



View in one of the Arden House meeting rooms finds TEC audience listening attentively to presentations

sions at national meetings of the Society.

Meetings

Discussions of meetings procedures continued under the chairmanship of Charles W. Parsons, chairman of the Meetings Committee. A show of hands indicated that the consensus of members present was that the Society would benefit by increased emphasis on Division Conferences with, perhaps, a reduction in emphasis on, or elimination of, Spring and Fall Meetings.

"Brainstorming"

On Monday afternoon members assembled in a group, preliminary to sessions of "brainstorming," defined as a "method encouraging informal, unrestricted production of ideas by groups."

After an introduction to the techniques of brainstorming, by T. A. Marshall, Jr., assistant secretary ASME, the group divided into five panels to consider problems faced by Divisions in organizing their conferences.

Ideas produced by each of the panels were later evaluated by another panel and reported to the group. A check list of the resulting suggestions will be made available to Division officers.

The evening session was devoted to a talk, "The Shape of Things to Come," by Joseph L. Kopf.

Division Conferences

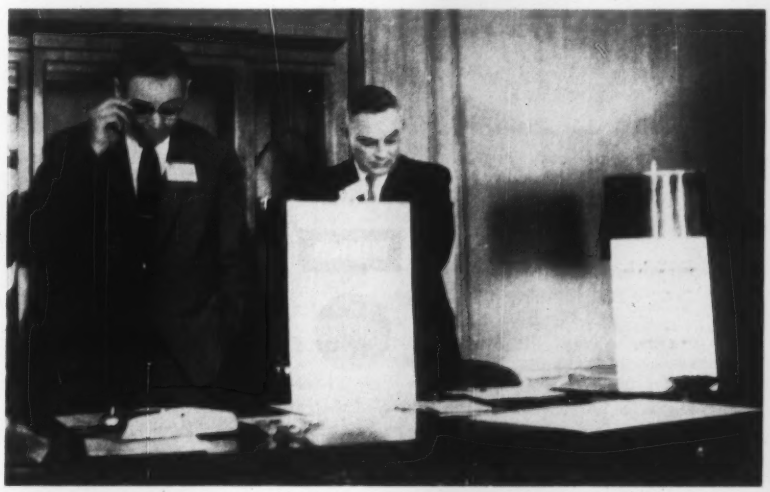
Under the chairmanship of Donald H. Cornell of the Professional Divisions Standing Committee there followed a review of some of the techniques and procedures successfully used by Divisions in the past.

Items covered included the use, by Oil and Gas Power Division, of a five-man executive committee working with a 28-man associate committee in order to distribute work among more members and develop a supply of executive committee personnel; a dual system used by Rubber and Plastics Division to cope with the divergent interests of its members; methods of securing, improving, and maintaining mailing lists, both through use of headquarters lists and with the cooperation of outside agencies.

There was further discussion of the methods used to select articles for publication by the Society and of procedures used to keep authors informed of the status of their papers.

R. H. Bacon opens fourth Technology Executives Conference at Arden House

ASME President W. F. Ryan welcomes group to meeting on Monday morning



T. A. Marshall, Jr., *left,* with Prof. R. G. Folsom assisting, lays down rules for "brainstorming" sessions

National Meeting Alterations Discussed

First item on Tuesday's agenda was a proposal by the 1956 ASME President Joseph W. Barker which called for alteration of the current system of national meetings in two major respects; elimination of Spring and Fall Meetings, thereby permitting the expenditure of more time and effort on Division Conferences, and limitation of papers at Annual and Semi-Annual Meetings to outstanding ones previously presented at Division Conferences.

Such an arrangement, Dr. Barker noted, would permit reduction of the number of simultaneous sessions at national meetings, encourage attendance by members at sessions sponsored by Divisions other than their own, and encourage presentation of major papers at Division Conferences.

Subsequent discussion centered on methods of improving the quality of papers at Division Conferences and of making more efficient the efforts of Divisions to improve and expand their operations.

There was a further review of the procedures governing selection of papers for publication by the Society and notifica-

History of TEC Conference and outline of program is given by A. W. Thorson

Current and projected ASME research activities are presented by E. M. Barber

W. E. Reaser reviews activities and problems of the Publications Committee

Discussions of meetings procedures are spearheaded by C. W. Parsons

D. H. Cornell presents problems of running Division Conferences

Past-President J. W. Barker proposes altering current system of meetings

tion of authors as to whether their papers are to be published or not.

Meeting Plans

Final session of the Conference was devoted to review of 1957 ASME meetings plans.

D. W. MacDougall, ASME meetings manager, reported that a program-planning report would be issued shortly. It was urged that all program planning groups make use of the report to help schedule as many joint conferences as possible.

Services which can be supplied by headquarters to assist in the operation of conferences were reviewed in detail.

There was a further discussion concerning publication of papers presented before Section and Division Meetings, and of procedures to be followed by Divisions which wish to arrange co-sponsorship of a national meeting session.

Engineering-Management Controls—Topic of ASME Management Conference

PLANS have been completed for the ASME Management Division Conference to be held in the Penn-Sheraton Hotel, Pittsburgh, Pa. on March 27 and 28. The conference is sponsored both by ASME and American Institute of Electrical Engineers.

The subject for this two-day conference will be "Engineering-Manpower Controls."

J. A. Hutcheson, vice-president of engineering and research, Westinghouse Electric Corporation, Pittsburgh, Pa. will address the members at luncheon on the first day of the conference. He has chosen as his topic "A Look Into the Future of Engineering." Dr. Hutcheson will attempt to predict some of the changes that will occur in engineering, using the year 2000 as a point of reference. He will show how the technical content of the over-all task of supplying materials and goods is increasing steadily. Dr. Hutcheson holds that the engineer of the future must be prepared to cope with increasingly difficult tasks.

Highlighting the conference will be the banquet on the evening of March 27 when President Ryan will address the members.

The conference will be concluded with afternoon sessions on March 28 following a luncheon at which H. Thomas Hallowell, Jr., president, Standard Pressed Steel Car Company, will speak on "Standardization—An Aid to Management Control."

Unclassified Engineering Materials Lists Available

THE AEC announced the publication of its first *Unclassified Engineering Materials List* (TID-4100). This list describes the engineering materials which have been received and cataloged, and which are available from the Technical Information Service Extension. The loose-leaf form of the list is intended to facilitate inclusion of supplements that will be issued from time to time as new materials are received and cataloged.

The introduction to this publication provides information on the organization and contents of the list and furnishes procedures for ordering drawings and related materials.

The Technical Information Service Extension is currently receiving additional unclassified engineering drawings and related materials from AEC sites. These will be cataloged and announced in future issues of the *Unclassified Engineering Materials Lists*. However, access permit holders should feel free to contact TISE on the availability of materials not appearing in the lists. If the materials desired are not already in the files of TISE, every effort will be made to obtain them from the originating AEC installation and to supply prints to the requester. Inquiries regarding the availability of engineering materials should be addressed to: U. S. Atomic Energy Commission, Technical Information Service Extension, P. O. Box 62, Oak Ridge, Tennessee, for the attention of the Engineering Materials Section.

An announcement will likewise be published regarding the availability of classified engineering materials as they are made available to the Technical Information Service Extension.

1957 American Power Conference Program Shows ASME in Large Role

THE American Power Conference, sponsored by Illinois Institute of Technology in co-operation with 14 universities and nine local and national engineering societies, of which The American Society of Mechanical Engineers is one, will be held on March 27-29, 1957, at the Sherman Hotel in Chicago, Ill.

The purpose of the conference is to provide a forum for the exchange of information in the fields of power generation, transmission, distribution, and utilization. The future of the coal industry also will receive attention at the three-day meeting. Another feature of the program includes a forum on trends in employment conditions for engineers sponsored by the Engineers Joint Council.

Registration and other information may be obtained from Dr. E. R. Whitehead, Secretary, American Power Conference, Illinois Institute of Technology, Chicago 16, Ill.

Sessions of particular interest to mechanical engineers have been selected from the preliminary program and are as follows:

WEDNESDAY, MARCH 27

9:00 a.m. — **Mezzanine Floor**

Registration

10:00 a.m. — **Grand Ballroom**

Opening Meeting

Chairman: *Allen Van Wyck*, president, Illinois Power Co., Decatur, Ill.

Co-Chairman: *W. A. Lewis*, professor of electrical engineering, Illinois Institute of Technology, Chicago, Ill.

Invocation: *The Reverend Iver G. Lawrence*, Chaplain, Illinois Institute of Technology, Chicago, Ill.

Similarities in the Technical Features of Nuclear Power Development in the United States and Other Countries, by *Walter Zinn*, president, General Nuclear Engineering Corp., Dunedin, Fla.

12:15 p.m. — **Bernard Shaw Room**

American Power Conference Luncheon

Sponsored by The American Society of Mechanical Engineers

Chairman: *R. S. Stover*, Vice-President, Region VI, ASME, Marshalltown, Iowa

Co-Chairman: *W. H. Pletta*, chairman, Chicago Section, ASME

Speaker: *D. S. Kennedy*, president, Edison Electric Institute; president, Oklahoma Gas and Electric Co.

2:00 p.m. — **Grand Ballroom**

Central-Station Steam Generators

Chairman: *H. L. Solberg*, head, School of Mechanical Engineering, Purdue University

Co-Chairman: *J. T. Anderson*, associate professor of mechanical engineering, Michigan State University

The Economic Effects of Steam Preheating Combustion Air on Air Heater and Economizer Surfaces, by *W. F. Portaline*, Foster Wheeler Corp., New York, N. Y.

Incorporating the Heat From the Stack Gases Into the Supercritical Heat Cycle at Eddystone Station, by *S. A. Arnow*, Philadelphia Electric Company, Philadelphia, Pa.

Operating Experiences With Twin Furnace Boilers, by *E. M. Powell*, Combustion Engineering, Inc., New York, N. Y.

Advances in the Field of Large Steam Generators, by *D. R. Wilson*, The Babcock and Wilcox Co., New York

2:00 p.m. — **Assembly Room**

Water Technology I

Chairman: *J. F. Wilkes*, director, Research Development, Dearborn Chemical Co., Chicago, Ill.

Co-Chairman: *M. B. Golber*, head power plant engineer, Armour and Co., Chicago, Ill.

An Application of Hot Lime Zeolite to Moderate High-Pressure Boiler Operations, by *Ben Varon*, Richfield Oil Company, Los Angeles, Calif., and *S. B. Applebaum*, Cochrane Corporation, Philadelphia, Pa.

Operation of a Large Hot Lime Zeolite System for High-Pressure Boilers, by *J. E. Hardin and Glenn Hull*, Standard Oil Company of Indiana, Whiting, Ind.

A Survey of Operating Plants, Problems, and Successful Operation, by *L. F. Wirth*, Ion Exchange Division, National Aluminate Corp., Chicago, Ill.

2:00 p.m. — **Crystal Room**

Space Heating

Chairman: *J. I. Yellott*, executive director, Association for Applied Solar Energy, Phoenix, Ariz.

Co-Chairman: *Gil Freyder*, engineer, Commonwealth Edison Co., Chicago, Ill.

The Place of the Heat Pump and Solar Energy in Space Conditioning, by *R. C. Jordan*, University of Minnesota

Electric Heating in the Tennessee Valley—A Pattern for the Future, by *W. R. New*, Tennessee Valley Authority, Knoxville, Tenn.

Air Conditioning With the Compound Heat Pump by *Sidney Miner*, York Corporation, Chicago, Ill.

8:00 p.m. — **Bernard Shaw Room**

Evening Forum

A forum devoted to the subject of Trends in Employment Conditions for Engineers will be sponsored by the Engineers Joint Council and will be composed of a number of outstanding industrialists and engineers who are cognizant of the situation throughout the United States. All are invited to attend and to participate in the informal discussion which will follow the introductory remarks.

THURSDAY, MARCH 28

9:00 a.m. — **Grand Ballroom**

Steam Turbines

Chairman: *Murray Joslyn*, vice-president, Commonwealth Edison Co., Chicago, Ill.

Co-Chairman: *R. Clay Porter*, professor of mechanical engineering, University of Michigan

Economics of Higher Pressures and Tempera-

tures for Steam Turbines in Industry, by *M. M. Patterson* and *W. B. Wilson*, General Electric Co., Schenectady, N. Y.

The Eddystone Superpressure Turbine, by *C. C. Franck*, Westinghouse Electric Corp., Philadelphia, Pa.

Advances in the Field of Large Steam Turbines, by *C. D. Wilson*, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

9:00 a.m. — Assembly Room

Water Technology II

Chairman: *S. F. Whirl*, chairman, Executive Committee, Engineers Society of Western Pennsylvania, and Chemical Operating Engineer, Duquesne Light Company, Pittsburgh, Pa.

Co-Chairman: *T. J. Hodan*, manager, Water Treatment Division, Allis-Chalmers Manufacturing Co., Milwaukee, Wis.

The Oxygen Hydrazine Reaction in Boiler Feedwater, by *N. L. Dickenson* and *I. N. Felgar*, The Babcock and Wilcox Co., Research Center, Alliance, Ohio.

Recent Application Results of the Hydrazine-Sodium Sulphite Combination, by *Robert Hess*, Connecticut Light and Power Co., Hartford, Conn.

Three Years' Experience With Hydrazine, by *M. D. Baker*, West Penn Power Co., Springdale, Pa.

Prepared discussions.

9:00 a.m. — Louis XVI Room

Hydroelectric Power Development

Chairman: *A. J. Ackerman*, consulting engineer, Madison, Wis.

Co-Chairman: *D. H. Madson*, department of mechanical engineering, State University of Iowa, Iowa City, Iowa.

Integration of Hydroelectric and Steam Power on the Pacific Gas and Electric System, by *Walter Dreyer*, Pacific Gas and Electric Co., San Francisco, Calif.

Economics of Power Generation for the TVA System, by *R. A. Monroe*, Tennessee Valley Authority, Knoxville, Tenn.

12:15 p.m. — Bernard Shaw Room

American Power Conference Luncheon

Sponsored by the American Institute of Electrical Engineers.

Chairman: *M. S. Coover*, president, American Institute of Electrical Engineers, Iowa State College, Ames, Iowa.

Co-Chairman: *E. R. Whitehead*, chairman, Chicago Section, AIEE, and head, department of electrical engineering, Illinois Institute of Technology, Chicago, Ill.

Speaker: *The Honorable Fred G. Aandahl*, Assistant Secretary of the Interior, United States Department of the Interior, Washington, D. C.

2:00 p.m. — Assembly Room

Water Technology III

Chairman: *M. D. Baker*, first vice-chairman, Joint Research Committee and chief chemist, West Penn Power Co., Springdale, Pa.

Co-Chairman: *Selden K. Adkins*, manager, Consulting Service, National Aluminate Corp., Chicago, Ill.

Report of Joint Research Committee, by *P. B. Place*, chairman, Joint Research Committee, West Penn Power Co., Springdale, Pa.

Counterflow Regeneration of Deionizers, by *P. H. Caskey*, Illinois Water Treatment Co., Rockford, Ill.

Anion Exchange Subfill as a Factor in Rinse Requirements of Demineralizers, by *R. Dvorin, J. H. Duff, J. Levendusky*, and *M. Lane*, Graver Water Conditioning Co., New York, N. Y.

2:00 p.m. — Crystal Room

Fuels

Chairman: *Louis C. McCabe*, president, Resources Research, Inc., Washington, D. C.

Co-Chairman: *Martin Elliott*, director, Institute of Gas Technology, Illinois Institute of Technology, Chicago, Ill.

Program to be Announced

3:30 p.m. — Assembly Room

Water Technology IV

Chairman: *W. L. Jackson*, chairman, Power Stations Chemistry Subcommittee of Prime Movers Committee, E. E. I., and Chemical Division Chief, Public Service Electric and Gas Co., Maplewood, N. J.

Co-Chairman: *W. R. Homan*, chief chemist, Commonwealth Edison Co., Chicago, Ill.

Aluminous Condenser Tubes—Report on a Plant Installation, by *W. A. Pollack*, Wisconsin Electric Power Co., Milwaukee, Wis.

Prepared Discussions: *R. A. Wilson*, Allis-Chalmers Manufacturing Co., Milwaukee, Wis., and *Ellis Verink*, Aluminum Company of America, New Kensington, Pa.

Method of Measurement and Recording of Small Concentrations of Oxygen Dissolved in Water, by *M. W. Greene* and *R. W. Negus*, Arnold O. Beckman, Inc., South Pasadena, Calif.

6:45 p.m. — Grand Ballroom

All Engineers Dinner

Presiding: *John W. Evers*, president, Commonwealth Edison Co., Chicago, Ill.

Entertainment: South Works Male Chorus of United States Steel Corporation, *Harry S. Walch*, director, *Isabel N. Ebert*, accompanist.

Speaker: *Gwilym A. Price*, president, Westinghouse Electric Corp., Pittsburgh, Pa.

FRIDAY, MARCH 29

9:00 a.m. — Grand Ballroom

Gas Turbines

Chairman: *Peter R. Broadley*, director, Locomotive Development Committee, Bituminous Coal Research, Inc., Dunkirk, N. Y.

Co-Chairman: *Warren E. Ibele*, department of mechanical engineering, University of Minnesota

An Operator's Evaluation of the Versatile Gas Turbine, by *G. H. Krapf*, United States Steel Corp., Chicago, Ill.

The Mene Grande Gas Turbine Plant, by *T. J. Putz*, Westinghouse Electric Corp., South Philadelphia, Pa.

Design and Characteristics of a Combined Gas and Steam Cycle for a 40,000-Kw Unit, by *A. R. LeBailly*, and *L. Skog, Jr.*, Sargent & Lundy, Engineers, Chicago, Ill.

Economics of Small Supercharged Plants, by *E. L. Richardson*, General Electric Company, Boston, Mass., and *E. L. Damin*, Foster Wheeler Corp., New York, N. Y.

9:00 a.m. — Louis XVI Room

Condenser and Feedwater Circuit

Chairman: *M. P. Cleghorn*, professor of mechanical engineering, Iowa State College, Ames, Iowa.

Co-Chairman: *Roy Sahlstrom*, Faville-LeVally Corp., Chicago, Ill.

Developments Covering Welding of Nonferrous Tubes in Steam Surface Condensers, *R. A. Wilson*, Allis-Chalmers Manufacturing Co.

Fundamental Need for Welding Nonferrous Tubes Into Feed Water Heaters, by *G. A. Worn*, The Lummus Company, New York, N. Y.

Progress Report on High-Speed Boiler-Feed Pumps, by *I. J. Karassik* and *T. W. Edwards*, Harrison Division, Worthington Corp., Harrison, N. J.

Boiler Feed Pumps for Supercritical Power Plants, by *Hans Hornschuch*, Ingersoll Rand Co., Phillipsburg, N. J.

10:30 a.m. — Louis XVI Room

Digital Computers for Mechanical Problems

Chairman: *Gerald V. Williamson*, vice president, Production and Distribution, Union Electric Co., St. Louis, Mo.

Co-Chairman: *Reno C. King*, associate professor of mechanical engineering, New York University

The Use of Digital Computers for Piping Flexibility Calculations, by *T. Kolflat* and *K. E. Knapp*, Sargent & Lundy, Engineers, Chicago, Ill.

Generalized Heat-Balance Computation on the IBM 650 EDPM, by *R. K. Large*, Detroit Edison Co., Detroit, Mich., and *J. E. Gerngross*, General Electric Co., Schenectady, N. Y.

12:15 p.m. — Bernard Shaw Room

American Power Conference Luncheon

Sponsored by the Western Society of Engineers

Chairman: *George L. Jackson*, president, Western Society of Engineers, Chicago, Ill.

Co-Chairman: *Harold B. Gotaas*, dean of the Technological Institute, Northwestern University, Evanston, Ill.

Speaker: *Gordon M. Freeman*, International President, International Brotherhood of Electrical Workers, Washington, D. C.

2:00 p.m. — Grand Ballroom

Nuclear Energy

Chairman: *Richard F. Humphreys*, assistant director, Armour Research Foundation, Chicago, Ill.

Co-Chairman: *A. H. Barnes*, director, reactor engineering, Argonne National Laboratory, Lemont, Ill.

Inter-American Progress Toward Economic Nuclear Power, by *W. F. Friend* and *L. F. C. Reiche*, Ebasco Services Inc., New York, N. Y.

Significant Developments in Large Boiling-Water Reactor Plants, by *R. C. Freeman*, General Electric Co., San Jose, Calif.

Plant Design and Operating Problems of the Pennsylvania Advance Reactor, by *W. E. Johnson*, Pennsylvania Advance Reactor Project, Pittsburgh, Pa.

A New Approach to the Design of Containment Shells for Atomic Power Plants, by *Alf Kolflat* and *W. A. Chittenden*, Sargent & Lundy, Engineers, Chicago, Ill.

2:00 p.m. — Louis XVI Room

Industrial Power Plants

Chairman: *F. G. Feeley, Jr.*, research and development department, Olin Mathieson Chemical Corp., New York, N. Y.

Co-Chairman: *Chester R. Earle*, executive editor, *Power Engineering*, Chicago, Ill.

A New Combined Steam-Gas Turbine Industrial-Power Plant, by *W. B. Wilson*, General Electric Co., Schenectady, N. Y.

Distribution of Steam and Electrical Power Costs in an Industrial Plant, by *H. P. Kallen*, associate editor, *Power*, New York, N. Y.

Incremental Efficiency Testing of Industrial Turbine Generators to Determine Steam Rates and Valve Points, by *G. L. Decker*, Dow Chemical Co., Midland, Mich.

Economic Dispatching of Industrial Turbine Generators by Valve Points Using a Digital Computer, by *A. D. Brooks*, Dow Chemical Co., Midland, Mich.

2:00 p.m. — Crystal Room

Symposium on Computers and Network Analyzers

Chairman: *H. L. Garbarino*, assistant chairman, electrical engineering research department, Armour Research Foundation, Chicago, Ill.

Co-Chairman: *James E. Van Ness*, associate professor of electrical engineering, Northwestern University, Evanston, Ill.

Application and Technical Uses of Digital Computers, by *L. W. Swanson*, Arthur Andersen and Co., Chicago, Ill.

The Role of an Independent Computational Facility in Power-Systems Engineering, by *R. B. Wise*, Armour Research Foundation, Chicago, Ill.

Potential Computer Applications in a Power Company, by *L. E. Jensen, T. W. Schroeder*, and *G. P. Wilson*, Illinois Power Co., Decatur, Ill.

Relation of Digital and Analog Computers in the Solution of Power-Systems Problems, by *D. B. Breedon* and *R. W. Ferguson*, Westinghouse Electric Corp., East Pittsburgh, Pa.

Third ASME IRD Conference Program Cosponsored by AIChE, April 7–10

The third annual conference of the Instruments and Regulators Division of The American Society of Mechanical Engineers will be held in the Northwestern Technological Institute Auditorium, Northwestern University, Evanston, Ill., April 7–10, 1957.

The theme of the conference is de-

veloped on "Applications of New Control Analysis Techniques" and the program is cosponsored by the Process Industries Division of the American Institute of Chemical Engineers, and the Chicago Section of ASME.

The tentative program follows:

SUNDAY, APRIL 7

2:00 p.m. Georgian Hotel, Evanston, Ill.
Registration

4:00 p.m.
Executive Committee Meeting

6:00 p.m. Tip Top Room, Georgian Hotel
Early Bird Social Hour

8:00 p.m.
Committee Meetings

MONDAY, APRIL 8

8:30 a.m. Auditorium, Northwestern Institute of Technology
Registration

9:30 a.m.
Session I

Chairman: *R. A. Clarridge*, Taylor Instrument Co., Rochester, N. Y.

Vice-Chairman: *W. D. Archibald*, Energy Control Co., New York, N. Y.

Multipliers or Nonlinear Compensation of Control Systems, by *D. Lebel* (Paper No. 57—IRD-1)

Algebraic Approach to Design of Automatic Controls,[1] by *R. Oldenburger*, Purdue University

Analysis of the Transient Response of Nonlinear Control Systems,[1] by *P. E. Grensted*

Statistical Treatment of Sampled Data-Control Systems for Random Inputs,[1] by *Masahiro Mori*

1:00 p.m. Sargent Hall, Northwestern University
Luncheon

2:30 p.m.
Session II

Chairman: *R. Oldenburger*, Purdue University

Vice-Chairman: *C. Concordia*, General Electric Co., Schenectady, N. Y.

Optimization of Time-Varying Linear Systems With Nonstationary Inputs, by *Shinbrot*

Design of Multivariable Optimum Filters,[1] by *J. H. Westcott*

Design of a Self-Optimizing Control System,[1] by *R. E. Kalman*

5:30 p.m. Georgian Hotel
Social Hour

7:30 p.m. Tip Top Room
Banquet

Speakers: *J. H. Rushton*, AIChE President

ASME Paper: **Some Dynamics of the Golf Shot,** by *A. J. Williams, Jr.*, Leeds & Northrup Co., Philadelphia, Pa.

TUESDAY, APRIL 9

8:30 a.m.
Registration

9:30 a.m.
Session III

Chairman: *W. E. Vannah*, editor, *Control Engineering*, McGraw-Hill Publishing Company, New York, N. Y.

Vice-Chairman: *A. R. Aikman*, Slumberger Instrument Co., Ridgefield, Conn.

Dynamic Response Study of a Mechanical-Hydraulic Frequency Discriminator Governor, by *C. C. Christianson* (Paper No. 57—IRD-14)

Correlation Functions and Noise Patterns in Control Analysis,[1] by *H. Thal-Larsen*

An Analog Study of a High-Speed Recording Servomechanism,[1] by *J. W. Swartzenberg*

Dynamic Study of an Experimental Pneumatic Process,[1] by *E. F. Hochschild*

[1] Papers not available—see box on page 314.

1:00 p.m.
Luncheon

2:30 p.m.
Session IV—Contributed by AIChE

Chairman: *P. S. Buckley*, E. I. du Pont de Nemours and Co., Wilmington, Del.

Vice-Chairman: *D. M. Boyd*, Universal Oil Products Company, Des Plaines, Ill.

Automatic Control in Continuous Distillation,[1] by *T. J. Williams* and *R. T. Harnett*

Closer Control of Loops With Flow Times,[1] by *O. J. M. Smith*

The Stability of Some Chemical Systems Under Control,[1] by *R. Aris*, University of Edinburgh, and *N. R. Amundson*, University of Minnesota

WEDNESDAY, APRIL 10

8:30 a.m.
Registration

9:30 a.m.
Session V

Chairman: *J. R. Davidson*, Taylor Instrument Co., Rochester, N. Y.

Vice-Chairman: *B. D. Harnsworth*, The Foxboro Co., Foxoboro, Mass.

Practical Aspects of Relay or Pulse Servomechanisms, by *Harold Adkins* (Paper No. 57—IRD-5)

A Linear Force-Input, Pneumatic Amplifier With Fast Response Characteristics, by *T. E. Hoffman* (57—IRD-4)

Dynamic Field Tests of a Steam Turbine and Dynamic Field Tests of a Process Furnace, by *P. R. Hoyt, B. D. Stanton*, and *D. C. Union* (Paper No. 57—IRD-15)

1:00 p.m.
Luncheon

12:45 p.m.
Inspection Trip

Field Trip and Luncheon at Panellit, Inc. and Powers Regulator Co.

2:30 p.m. Georgian Hotel
Executive Committee Meeting

WOMEN'S PROGRAM

Sunday, April 7—5:30 p.m.: Early Bird Social Hour—Georgian Hotel (All conferees invited)

Monday, April 8—10:00 a.m.: Coffee—"Get Acquainted"—Bergmann Residence, 556 Earlston Road, Kenilworth. Transportation furnished by Chicago Ladies Auxiliary

2:00 p.m.: Tour of Campus

5:30 p.m.: Social Hour

7:30 p.m.: Banquet

Tuesday, April 9—10:00 a.m.: Grand Tour of Chicago and Luncheon at Chiam's Restaurant. Ladies Headquarters: Georgian Hotel

Committee Meetings

Sunday, April 7—	Orrington Hotel
Executive Committee	1:30 p.m.
Sunday, April 7—	
Design Committee	3:30 p.m.
Application Committee	3:30 p.m.
Theory Committee	3:30 p.m.
Dynamics System Committee	3:30 p.m.
Terminology Committee	8:00 p.m.
Education Committee	8:00 p.m.
Long Range Planning	8:00 p.m.
Wednesday, April 10—	
Executive Committee	1:30 p.m.

The fourth IRD conference will be held at the University of Delaware, Newark, Del., March 31-April 2, 1958

Second ASME Design Conference at New York Coliseum Again Teamed With Design Engineering Show

Thousands of engineers planning to sit in sessions and see Design Engineering Show

METHODS for the development of new designs by American industry will feature the second annual Design Conference sponsored by the Machine Design Division of The American Society of Mechanical Engineers.

The conference will be held in conjunction with the Design Engineering Show at the New York Coliseum, May 20 to 23. The show, produced by Clapp & Poliak, Inc., New York exposition management firm, will be one of the five largest annual industrial expositions to be held during 1957.

Editors Serve as Chairmen

The editors of four leading design publications in the field will serve as chairmen of a number of the conferences. They include: Colin Carmichael, editor, *Machine Design;* Henry C. Clauser, editor, *Materials & Methods*, George F. Nordenholt, editor, *Product Engineering*, and Frank Oliver, editor, Electrical Manufacturing.

Technical Discussions

The entire first day will be devoted to a panel discussion, "Procedures in Developing New Designs." On the next two days, the conference sessions will be divided into three groups to consider mechanical, materials, and electrical aspects.

The second day's mechanical session will discuss "New Developments in Design and Application of Gearing" and "New Developments in Design and Application of Cams." The materials session will discuss metallic materials and ceramics and refractory materials. "Selecting Motors with New NEMA Frame Sizes" and "Static vs. Contactors Controls" will make up the electrical session.

On the third day, the mechanical session will discuss "Designing Parts for Easiest Machining, Handling, and Assembly" and "Hopper Feeding"; the materials session will discuss plastics and rubbers, and coatings and finishes, and the electrical session will discuss "Numerical Control for Machinery" and "Designing Machines for Automatic Controls."

Design Engineering Show

The show, which rocketed to a position among the top five in only one year, will occupy three floors of the Coliseum and has been virtually sold out for months. It will be two-and-one-half times the size of the initial show in Philadelphia, Pa., in 1956.

Attendance, which is expected to reach the 20,000 mark, will be representative of almost every major corporation in the country and visitors from at least a dozen foreign countries are expected.

Exhibits will show products which go into the making of other products. These include mechanical, electrical, hydraulic, and pneumatic components; metallic and nonmetallic materials; fasteners; finishes and coatings; shapes and forms, and accessories to product development.

In the past, design engineers were required to attend a number of expositions to keep abreast of new developments in their field.

Although several of the shows had exhibits which featured design components or materials among their booths, no single show was devoted exclusively to the design engineer's needs.

First ASME Railroad Division Conference Program, Chicago, Ill., April 25-26

THE Railroad Division of The American Society of Mechanical Engineers will hold its first conference at the Sheraton Hotel, Chicago, Ill., April 25–26, 1957.

The preliminary technical program offers 11 papers by specialists engaged in this field of engineering. W. F. Ryan, ASME President, will address the banquet, and J. P. Kiley, president of the Chicago, Milwaukee, St. Paul and Pacific Railroad, will be luncheon speaker on opening day of the conference.

An amusing and enjoyable program has been arranged for the women who will be accompanying their husbands at the meeting.

Technical Program

The preliminary program is as follows:

WEDNESDAY, APRIL 24

1:00 p.m. — **Parlor 809**

Registration

THURSDAY, APRIL 25

9:00 a.m. — **Boulevard Room**

Session 1

Chairman: *M. A. Pinney*, engineer of tests, Pennsylvania Railroad, Altoona, Pa.

Vice-Chairman: *A. G. Hoppe*, consultant

Color motion picture: **What Is a Mechanical Engineer?**

Notes On The Use of Catalytic Cracked Fuels in Diesel Locomotives,[1] by *E. H. Weston*, American Steel Foundries, Chicago, Ill.

Use of Economy Fuels on Diesel Locomotives,[1] by *P. V. Garin*, Southern Pacific Co., San Francisco, Calif.

The Use of Economy Fuels on Locomotives, by *Ray McBrian*, Denver & Rio Grande Railroad Co., Denver, Colo. (Paper No. 57—RR-6)

12:00 noon — **Boulevard Room**

Luncheon

12:00 noon — **Tropical Room**

Cocktails

Chairman: *F. K. Mitchell*, chairman, Railroad Division of ASME

Speaker: *J. P. Kiley*, president, Chicago, Milwaukee, St. Paul and Pacific Railroad

12:00 noon — **Kungsholm Restaurant**

Women's Auxiliary Luncheon

Chairman: *W. H. Oldacre*, Chicago, Ill.

Party will leave registration desk on fifth floor at 11:30 a.m. sharp to go to the restaurant

2:30 p.m. — **Boulevard Room**

Session 2

Chairman: *Eric Wynne*, chief of motive power and car equipment, Canadian National Railways

Vice-Chairman: *J. L. Robson*, chief mechanical officer, Great Northern Railway Company, St. Paul, Minn.

Test Equipment for Use in Diesel Locomotive Maintenance,[1] by *R. W. Seniff*, Baltimore & Ohio Railroad, Baltimore, Md.

Test Equipment for Use in Diesel Engine Maintenance, by *J. A. Smith*, New York Central System (Paper No. 57—RR-4)

5:30 p.m. — **Foyer**

Cocktails and hors d'oeuvres

7:00 p.m. — **Grand Ballroom**

Banquet

Chairman: *F. K. Mitchell*, chairman, ASME Railroad Division

Speaker: *W. F. Ryan*, President, The American Society of Mechanical Engineers

FRIDAY APRIL, 26

8:00 a.m. — **Spanish Court**

Registration

9:00 a.m. — **Tropical Room**

Session 3

Chairman: *J. W. Hawthorne*, general superintendent motive power and equipment, Atlantic Coast Line

Vice-Chairman: *R. E. Taylor, Jr.*, mechanical engineer, Chicago, Burlington and Quincy Railroad

Roller Freight Needs Better Trucks, by *J. L. Haynes*, consultant (Paper No. 57—RR-3)

Draft Gear Development,[1] by *W. D. Wallace*,[1] W. H. Miner, Inc.

Trailers on Flat Cars,[1] by *N. E. Carlson*, American Car & Foundry

12:00 noon — **Boulevard Room**

Luncheon

Chairman: *F. K. Mitchell*, chairman, Railroad Division of ASME

2:00 p.m. — **Tropical Room**

Session 4

Chairman: *W. M. Keller*, executive vice-chairman and director of research, A.A.R.

Vice-Chairman: *F. Fahland*, general mechanical engineer, Union Pacific Railroad

Corrosion Prevention of Railroad Equipment, by *J. W. Crossett*, International Nickel Co. (57—RR-1)

The Expanding Use of Aluminum in Railroad Cars, by *G. B. Hauser*, Development Division, Aluminum Company of America (57—RR-2)

Aluminum in Freight Cars,[1] by *C. O. Burell*, Kaiser Aluminum Co.

Committee Meetings

All-Committee meeting is scheduled for Parlor 810, at 4:00 p.m., April 24, 1957.

Executive Committee RR-1, Chicago Committee RR-4, and Cleveland Committee are scheduled for Parlor 809–810, at 5:00 p.m., April 26, 1957.

Parlors 809–810 will be available for impromptu meetings and official gatherings throughout the conference from 8:00 a.m. to 5:00 p.m. except as noted above.

[1] Papers not available—see box on this page.

Orders for Technical Papers

ONLY copies of numbered ASME papers will be available. Some of these papers may not be available in time to permit your receiving them in advance of the conference. Your order will be mailed only when the complete order can be filled unless you request that all papers available ten days before the conference be mailed at that time. Please order only by paper number; otherwise the order will be returned. The final listing of available technical papers will be found in the issue of MECHANICAL ENGINEERING containing an account of the conference.

Copies of ASME papers may be obtained by writing to the ASME Order Department, 29 West 39th Street, New York 18, N. Y. Papers are priced at 25 cents each to members; 50 cents to nonmembers. Payment may be made by check, U. S. Postage Stamps, free coupons, or coupons which may be purchased from the Society. The coupons in lots of ten are $2 for members; $4 for nonmembers.

Copies of the unnumbered papers, listed in the program, are not available because the review of these manuscripts had not been completed when the program went to press. The author's name and paper number will appear with the paper title in the program as well as in the issue of MECHANICAL ENGINEERING containing an account of the conference.

Industry Participates in Exchange of Students for Technical Experience

Each year, under the program of the International Association for the Exchange of Students for Technical Experience, IAESTE, U. S. industries are asked for summer industrial placements for foreign science and engineering students. The request is made by the Institute of International Education as the administering agency for the IAESTE program. Placements include a maintenance allowance for the foreign student plus a nominal administrative fee to cover program costs. Since the IAESTE program is reciprocal, the number of placements offered by American business to foreign students determines in general the number of American students who will have the opportunity to train abroad.

Last summer, 45 U. S. firms received 75 students from abroad, while 58 American students of science and engineering trained in 13 European countries. The U. S. IAESTE National Committee met early in the fall at the Institute of International Education to evaluate the 1956 program and to make plans for increased activity in 1957.

American Participation

Reports on the program indicate that American participation increased markedly during the year since the Committee's establishment. Although the increase is a substantial one, American participation is still far below that of the leading European countries. The Committee voiced the hope that there would be even greater participation in the program by American industry in 1957.

Under this unique program, in which 22 countries participate, students are sent abroad for training in industry during their summer vacations. In 1956, over 2500 industries in these countries provided training for more than 5700 visiting students from other member countries. Each of IAESTE's member-countries finances its own operations; that of the U. S. Committee is supported by the nominal administrative fee charged to participating firms and students.

Commenting on this international training program, Maynard M. Boring, Mem. ASME, Chairman of the IAESTE Committee, Manpower Consultant for General Electric, and past-president, American Society for Engineering Education, said, "Here is a most positive means of providing a more rounded background for student engineers. The IAESTE program has immense potential at a time when this country suffers from a critical shortage of engineers and is looking for new and improved training methods for its engineering students. American business has much to offer and much to gain from IAESTE."

The Institute of International Education co-ordinates U. S. participation in the IAESTE program. The U. S. IAESTE Committee advises the Institute on the program. Members of the Committee include executives of leading industrial and professional societies as well as faculty members of engineering schools and representatives of student organizations.

U. S. Colleges Nominate American Students

U. S. colleges are asked to nominate American students of engineering and the sciences who wish practical training abroad. Each applicant must have completed his third year of study, must have had practical experience in this country, and must be able to pay for his international travel. Endorsement by an official of the candidates' schools is required with regard to the students' general and technical qualifications. The 58 U. S. students who trained abroad in 1956 represented 24 American colleges.

U. S. Firms Take Part

Of the 45 U. S. firms welcoming foreign trainees this year those taking the largest numbers were: General Electric Company, Schenectady, N. Y., and branches, 11; Colorado Department of Highways, Denver, 5; Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., 4; American Radiator and Standard Sanitary Corporation, Louisville, Ky., 3; Bechtel Corporation, San Francisco, Calif., 3. Companies taking two students each were: Air Preheater Corporation, Wellsville, N. Y.; Bell and Howell Company, Chicago; Bell Telephone Laboratories, N. Y.; Crown Zellerbach Corporation, San Francisco; Fedders-Quigan Corporation, Buffalo, N. Y.; Four Wheel Drive Auto Company, Clintonville, Wis.; International Harvester Company, Chicago; Jackson and Moreland, Boston; National Cash Register Company, Dayton, Ohio; Standard Oil Company (Ohio), Cleveland. The remaining 30 industries which accepted one trainee each included some of the nation's leading companies in the field of mechanical and electrical equipment, airplane construction, power, and mining.

A pamphlet describing the program is available from the Institute of International Education. Industries interested in this exchange are advised to address their requests to the Secretary U. S. IAESTE Committee, Institute of International Education, 1 East 67th Street, New York 21, N. Y.

1957 Annual Conference Program of the Textile Engineering Division Announced

The 1957 Annual Conference of the Textile Engineering Division of The American Society of Mechanical Engineers will be held at the Lowell Technological Institute in Lowell, Mass., on April 12, 1957.

Sponsored by the Boston Section, ASME, with the co-operation of the Lowell Technological Institute, the conference will be centered about the theme of "Quality."

One of the high lights on the program will be a luncheon speech by William F. Ryan, ASME President.

The tentative program is as follows:

FRIDAY, APRIL 12

8:30 a.m.

Registration

9:30 a.m.

Session I

Chairman: *H. W. Ball*, Foster Machine Co., Westfield, Mass.

Vice-Chairman: *V. F. Sepavich*

Merchandising Looks at Quality, by *J. B. Goldberg*, consultant, New York, N. Y.

Quality and Textile Machinery, by *J. K. Frederick*, Lowell Technological Institute

Quality-Control Techniques, by *O. T. Beckwith*, The William Carter Co., Needham, Mass.

12:30 p.m. **At the Institute**

Luncheon

Toastmaster: *F. W. Ball*, chairman, Textile Engineering Division, ASME

Speaker: *W. F. Ryan*, President, ASME

2:30 P.M.

Session II

Chairman: *K. N. Fox*

Vice-Chairman: *F. N. Fitzgerald*

Role of Research for Improving Quality, by *W. J. Hamburger*, Fabric Research Laboratories, Inc., Needham, Mass.

Cost Versus Quality, by *W. F. Atwood*, Pepperel Manufacturing Co., Boston, Mass.

Junior Forum

Conducted for the National Junior Committee

By H. N. Weinberg[1], Assoc. Mem. ASME

Trends in Professional Compensation

By Edward B. Peck

In a paper entitled "Trends in Professional Compensation," Edward B. Peck of Rutgers University presents a quantitative analysis of the trends in the earnings of engineers.

Professor Peck's paper was presented as part of the panel on "The Economic Status of the Engineer" held during the Engineers Joint Council General Assembly, Jan. 17–18, 1957, in New York, N. Y. (See pages 299–300 of this issue for a report on the assembly.) The EJC report, "Professional Income of Engineers—1956," provided the statistical data for his paper.

The opinions expressed are considered of such wide interest that this month's Junior Forum is devoted entirely to bringing the following salient facts set forth in the paper to the attention of its readers:

Squeezing of Middle-Class Salaries

There is a great deal of interest in engineers' and scientists' pay, that is the reason the American Chemical Society published a salary survey in 1955 and the EJC does now. There have been a lot of publications on the subject that emphasize "telescoping salaries." This means that engineers' salaries do not grow with experience as much as they used to. A similar telescoping is observed in merit differentials. This exemplifies what has happened to all middle-class salaries. Most of the upper middle class has been squeezed by the social and economic leveling in our economy.

Productivity and wages have been rising rapidly, while top salaries have, until quite recently, remained static. This has produced the squeeze or telescoping that has reduced experience and merit incentives. There is much talk about other incentives besides pay and they are important. But the crux of the incentives that industry can offer is pay. Others have a hollow ring when pay is not about right.

This paper presents an analysis of engineers' salaries from 1939 to 1956 in relation to the important economic factors; productivity, wages and consumers' costs. It proposes a framework of salary administration that takes account of the factors, experience, merit, and the economic trends.

Engineers' Salaries—1956

The 1956 Salary Survey of the Engineers Joint Council, for engineers employed in industry is summarized graphically in Fig. 1. The co-ordinates are salary in current dollars per year and experience as measured in years from first or bachelor's degree (YFD). The curves show the percentile salaries as they vary with experience (YFD). The top line represents the minimum salary of the top 10 per cent of engineers as it varies with experience. The lower lines have the same significance for the other percentiles.

The horizontal lines at $8300 and $7600 represent craftsmens' pay. They are for one year at full time and without overtime. It is considered appropriate to compare engineers' salaries with craftsmens' wages because they are alternate careers for young men capable of becoming engineers.

The median salary curve for engineers intersects the craftsmens' wages at 7.5 and 10 years' experience. This means that the average engineer is 30 years old before he catches up with the plumbers and bricklayers. When the pay represented here is integrated over a career of 43 years (age 22 to 65), the median salary of engineers exceeds the carpenters by about $80,000 and the plumbers by less than $50,000. This is not an attractive return on the investment for an engineering education.

The Trend in Salaries, 1939–1956

The period 1939–1956 has been one of great economic expansion. The gross national product measured in current dollars increased more than fourfold, while the cost of living index about doubled. Wage rates increased about threefold while top-management salaries increased even less than the cost of living. Most all middle-class salaries were squeezed between rising wages from below and a relatively static top management salary.

In the 1939–1956 period the incentive of increased pay with experience was reduced about half. There were 30 raises of 5 per cent each along the engineers' median salary curve in 1939 and only 15 in 1956. Of course this is magnified by the more rapid increase in starting salaries, but it is nevertheless a reduced incentive.

The merit incentive is not distorted by high starting salaries. It dropped at mid-career (20–24 YFD) from 233 per cent in 1939 to 92 per cent in 1956. This is measured as the difference between the 90th and 10th percentile salaries at 22 YFD as shown here.

Engineers' Salaries: Trend in Merit Spread

Percentage Difference In Percentile Salaries At 20–24 Years' Experience Level.

Year	50th to 10th	75th to 25th	90th to 10th
1939	96%	86%	233%
1946	80	59	169
1952	.	48	.
1956	50	49	92

It is interesting to see what engineers' salaries would be in 1956 if those in the 1939 survey had been increased by the same factor as wages. The starting salaries would be a little lower than now. The median would rise to $16,000 per

E. B. Peck, Rutgers University professor, speaks on "Trends in Professional Compensation" at EJC third General Assembly, Jan. 17, 1957. Dr. Peck's paper was presented at panel on "The Economic Status of the Engineer."

[1] Process Engineer, Esso Research and Engineering Company, Linden, N. J.

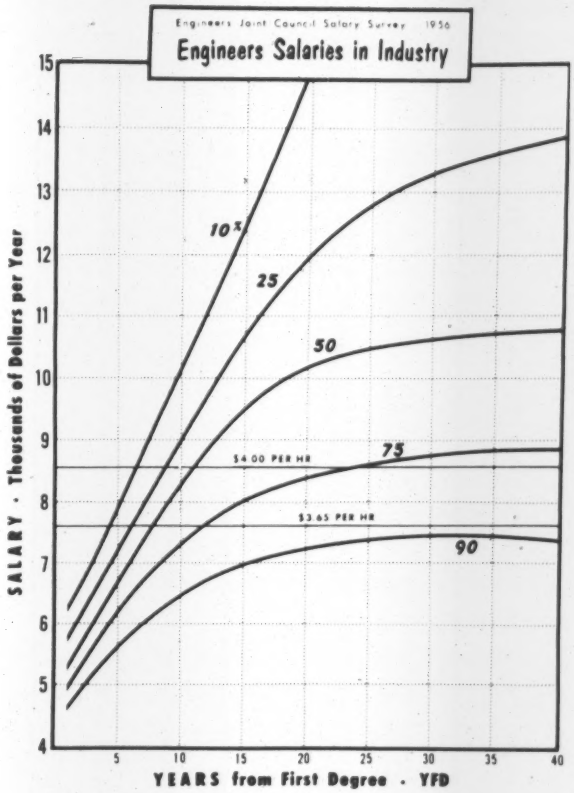


Fig. 1 Engineers' salaries in industry graphically summarized from 1956 Engineers Joint Council survey

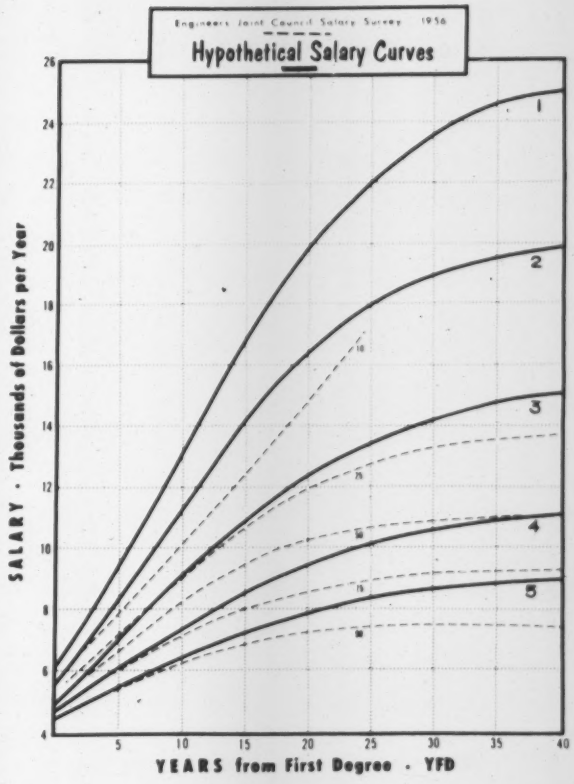


Fig. 2 Hypothetical salary curves covering 40-year span of an engineer's professional career

year at mid-career compared to about $10,000 now. The curve would end at about $20,000 compared to $11,000 now. The bottom curve would end at over $11,000, and the 10th percentile at mid-career would be $30,000, compared to $15,000 now.

Engineers' Salaries

It seems appropriate to suggest that engineers' salaries go up by the same percentage amount as wages until one realizes what that would do to the other relationships. The compensation for the entire upper middle class has been contracted with engineers' salaries. When taxes and other things are considered, the higher the salary, the more it has lost ground with respect to labor. It is a complicated matter to adjust engineers' salaries so that merit and experience incentives are re-established. Some industrial organizations have adopted the principle of raising all salaries by the same percentage as wages. Civil Service has not, and there are degrees of difference in between.

Future Outlook

The economic outlook is for a secular growth of about 3 per cent per year. Wages are expected to go up at least as fast because labor's co-operation and buying power are also needed. This means that wages will at least double in less than 25 years. It is significant that this kind of increase is granted without regard for individual merit or productivity. It is strictly a national secular trend. It seems that engineers' salaries will have to respond to this secular trend. It should be on an equitable basis to all without reference to individual merit or productivity. Otherwise it is quite possible that our economic progress will run down, for the lack of sufficient incentives to develop the essential technology.

A Pattern for Merit and Promotional Salary Administration

Each engineer has a professional career of 40-odd years. This emphasizes the fact that a good engineer is the equivalent of a large capital asset. It is important therefore, to develop a system of salary administration that will sustain the will to be productive over a whole career.

A variety of plans have been developed for using a salary survey as a guide in salary administration. They have met with varying degrees of success. At best, they supplement good job evaluation and merit rating. The following analysis is based on a plan that has been moderately successful for ten years.

The survey, Fig. 1, shows salaries at a particular time. And it shows relationships for merit and experience at that time. When a general salary adjustment occurs, as with wages, and without regard to merit or experience, the survey and salary chart are obsolete. A new one must be made. It is therefore desirable to have a formula for making each succeeding chart.

The next thing to observe is that salary curves run for a whole career of 40-odd years, and salaries increase with experience for the whole period. It is presumed that the main purpose of merit and promotional raises is to provide incentive

for improved and sustained productivity. These incentives should be provided for the whole career.

The next problem is to develop a rational and equitable system for all levels of merit. The only curve in Fig. 1 that suggests a regular annual percentage increase in salary with experience is the top 10th percentile curve. The other curves flatten out with increased experience like a parabola. Does this represent a different salary policy for all but the top 10 per cent? This query can be objectively answered when all these curves are represented by a single equation. The analysis of earlier surveys together with an analysis of annual merit and promotional increases as a function of experience, showed that several equations could be used. The one selected, when translated into words offers a simple and equitable statement for salary policy. At the same time, it presents a sound formula for budget control.

The equations say that at any merit level, the annual rate of salary increase is proportional to the salary, multiplied by the amount of money left for salary increases for the rest of the career. These salary curves suggest that each curve is aimed at a goal which is a potential for the employee. It does not mean that an employee is tagged with a potential early in his career and has to live with it. Periodic merit rating and performance reviews change these potentials.

The mathematics of this statement is as follows:

$$dS/dt = kS(A - S)$$

Where S is the salary, t is the experience or YFD in years, k is a constant computed for each curve from the end conditions. A is the potential salary or asymptote of each curve.

This is the equation for the set of curves presented in Fig. 2, running from the starting salaries in the survey to $25,000, $20,000, $15,000, $11,000, and $9000, respectively, at 40 YFD. In practice the curves might run from starting salaries to the maximum salaries of job classifications. This relates the curves to the job-evaluation system. It also allows for a definition of potential in terms of job specifications.

Conclusions

Engineers' salaries have not kept up with national productivity and wages. Probably most upper middle-class wages have reacted in much the same way.

This condition is largely attributed to the attitudes on salaries that prevailed up to about 1952. Salary and wage increases were related to cost of living and cents per hour rather than a percentage increase. Since 1952 the percentage principle seems to prevail.

Another factor in holding down older engineers' salaries was the failure to separate general raises from merit and promotional raises.

It is proposed that salary administration recognize and take account of three independent factors. The first is the secular trend or general increase that is granted to all without regard to individual experience or merit. The next factor is experience, which must be taken account of throughout the whole career. The percentile curves suggest this trend. Finally, there should be re-established a merit differential that has real incentive value.

A pattern for pricing different degrees of experience and merit is proposed. It is reduced to formulas that start a salary policy, and provide flexibility for changes due to the secular trend.

1957 ASME Regional Student Conferences

	REGION	PLACE	DATE	HOST
I	New England	Medford, Mass.	April 12–13	Tufts University
II	Eastern	New Brunswick, N. J.	April 12–13	Rutgers University
III	Alleghenies	Washington, D. C.	March 29–30	The Catholic University of America
IV	Southern	Birmingham, Ala.	April 5–6	Alabama Polytechnic Institute University of Alabama Mississippi State College
		(In conjunction with the RAC Meeting of April 6–7)		
V	Midwest	Cincinnati, Ohio	April 18–19	University of Cincinnati
VI	Northern Tier	Madison, Wis.	April 5–6	University of Wisconsin
VI	Southern Tier	Evanston, Ill.	May 2–3	Northwestern University
VII	Pacific Northwest	Seattle, Wash.	May 9–10	University of Washington
VII	Pacific Southwest	Reno, Nev.	April 26–27	University of Nevada
VIII	Northern Tier	Stillwater, Okla.	April 29–30	Oklahoma A&M College
VIII	Southern Tier	Lubbock, Texas	March 22–23	Texas Technological College
VIII	Rocky Mountain Tier	Denver, Colo.	April 12–13	University of Denver

Wood Industries Conference on May 16–17 to Feature "Automation in Woodworking Plants"

Winston-Salem, N. C., will be the site for the 1957 Wood Industries Conference on May 16–17. The two-day program, built around the theme of "Automation in Woodworking Plants," will feature speakers from all parts of the nation.

Although the conference is being held in one of the largest furniture manufacturing centers in the world, the subjects to be discussed encompass a much larger scope. Several papers will be given on automatic sanding and milling. The effect of mechanization on factory cost in production will be shown. ASME President William F. Ryan will address the banquet on May 16. The program will also include a panel discussion on core materials. On the final afternoon of the meeting, inspection trips will be conducted to some of the most modern and mechanized plants in the area.

A complete program will be published in the April issue.

ASME Coming Events

March 10–15
Nuclear Congress, Conventional Hall, Philadelphia, Pa.

March 18–21
ASME Gas Turbine Power Conference, Hotel Sheraton-Cadillac, Detroit, Mich.

March 27–28
ASME Engineering Management Conference, Hotel William Penn, Pittsburgh, Pa.

April 7–10
ASME Spring Meeting, Hotel Dinkler-Tutwiler, Birmingham, Ala.

April 8–10
ASME Instruments and Regulators Conference, Northwestern University, Chicago, Ill.

April 25–26
ASME Railroad Conference, Hotel Sheraton, Chicago, Ill.

April 25–26
ASME-SAM Management Conference, Hotel Statler, New York, N. Y.

May 16–17
ASME Wood Industries Conference, Winston-Salem, N. C.

May 19–23
ASME Oil & Gas Power Conference, Kentucky Hotel, Louisville, Ky.

May 20–23
ASME Design Engineering Conference, Coliseum, New York, N. Y.

June 9–13
ASME Semi-Annual Meeting, Sheraton-Palace Hotel, San Francisco, Calif.

June 13–15
ASME Applied Mechanics Conference, University of California, Berkeley, Calif.

August 11–15
ASME Heat Transfer Conference, Pennsylvania State University, University Park, Pa.

Sept. 9–13
ASME IRD-ISA Conference, Auditorium, Cleveland, Ohio

Sept. 22–25
ASME Petroleum Mechanical-Engineering Conference, Hotel Mayo, Tulsa, Okla.

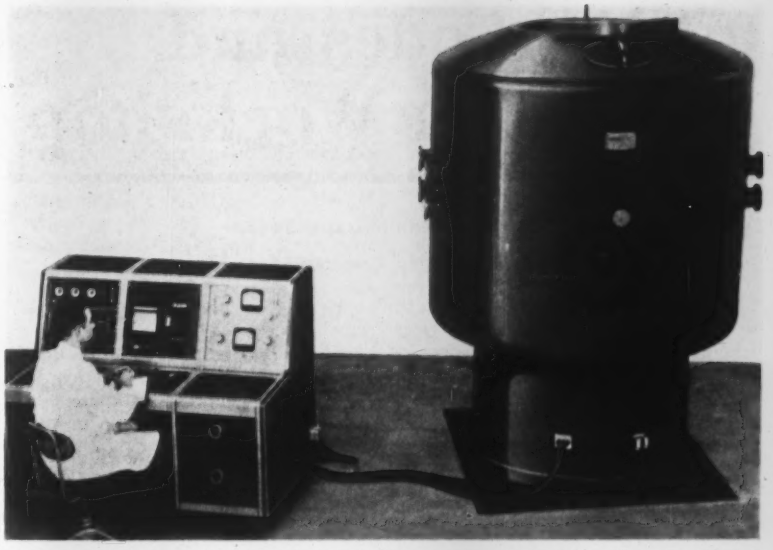
Sept. 23–25
ASME Fall Meeting, Hotel Statler, Hartford, Conn.

Oct. 7–9
ASLE-ASME Lubrication Conference, concurrently with ASME-IMechE International Conference on Lubrication and Wear, Royal York Hotel, Toronto, Ont., Canada

Oct. 8–12
ASME-AIME Fuels Conference, Chauteau Frontenac, Quebec, Que., Can.

Dec. 1–6
ASME Annual Meeting, Hotel Statler, New York, N. Y.

(For Meetings of Other Societies, see page 304)



Visitors to the International Atomic Exposition and 1957 Nuclear Congress, March 11–15, at Philadelphia (Pa.) Convention Hall, will inspect a critical nuclear reactor in actual operation. Aerojet General reactor is approved by AEC as completely safe for public exhibition without special shielding. Developing a normal output of 100 milliwatts with a peak of 3 watts, the reactor, *right,* which includes a remote control console, *left,* is designed for use in hospitals, educational institutions, and industry. All shielding required has been built into the reactor so that it is completely self-contained. It is about 9 1/2 ft high, weighs 22,000 lb, and is operated with enriched U-235 uranium in the form of a powder dispersed in solid polyethylene plastic.

Reminder to ASME Members

The time is fast approaching when members of the National Nominating Committee will be meeting to select the nominees for office in The American Society of Mechanical Engineers.

This democratic process of Society government can only be promulgated by your active participation in the mechanics. If you have any specific names to submit for nominations, now is the time for you to help fill the slate.

You may, therefore, make your nomination through your Section representative or directly through Raymond H. Stockard, Secretary of the 1957 National Nominating Committee, University of Rhode Island, Kingston, R. I. Your nomination must be on forms which may be obtained from members of the Nominating Committee as well as from headquarters.

Members are reminded that in accordance with the Society's Constitution, candidates for office of President, Vice-Presidents, and Directors shall be of the grade of Fellow or Member. Members wishing to speak in support of any proposed nominee have the privilege of appearing before the National Nominating Committee at a meeting to be held during the Semi-Annual Meeting in San Francisco, Calif., Hotel Sheraton-Palace, June 10 and 11, 1957.

You are also reminded that the proposed nominees for officers are to be men who are responsible individually and collectively for the administration of your Society. They are the trustees for the Society, a corporation with more than a million dollars in assets and an annual income of more than $2 million. These officers are to be regarded by the members of the Society and the public as leaders in their profession.

As officers, they are expected to possess those qualities of character, vision, leadership, responsibility, and broad understanding that will justify the faith of the members. As these men must stand before the public, they should preferably possess abilities of dignified public address.

Make your nominations known to your Section representative who, in turn, is a member of the Regional Nominating Subcommittee. The organization of the 1957 National Nominating Committee was published in the August, 1956, issue of Mechanical Engineering, pp. 773–774.

ASME Codes and Standards Workshop

Determining the Dust Concentration in a Gas Stream

By Melvin D. Engle, Chairman of PTC Committee No. 27

With the increasing public awareness of air pollution, there has come a great need for a technically correct yet practical method of determining the dust concentration in a gas stream. PTC 27-1957, "Test Code for Determining the Dust Concentration in a Gas Stream," soon to be released by the Power Test Codes Committee, has been prepared to fulfill this need.

Gas flows in ducts in commercial installations in a turbulent manner and the velocity at various points in the duct varies widely; across the width of the duct and from top to bottom. Guide vanes and perforated plates can be used to materially improve these variations in velocity.

Dust concentrations in a gas stream in a duct vary widely for many reasons. Unfortunately, the guide vanes which help smooth out velocity variations, quite often accentuate the variation in dust concentration. Dust concentrations in the gas stream may vary because of: (*a*) Variations in gas velocity in the duct; (*b*) the density of the dust particles; (*c*) the shape of the dust particles; or (*d*) the separating action of changes in direction of the duct upstream from the sampling point.

This new test code provides a time-tested method for accurately determining the dust concentration in a gas stream. It has been used by many test engineers for thousands of tests and has been proved a practical method. It is undoubtedly the best method known today.

Illustrations have been added to the code to show some of the problems connected with tests to determine dust concentrations.

The code points out quite bluntly that single-point dust-concentration determinations are useless and actually dangerous.

The principal requirements for determining the dust concentration in a gas stream are:

1 Sampling tube should face directly into the gas stream.

2 The gas velocity in the sampling tube should be the same as the velocity in the duct.

3 A good filter for separating the dust from the gas sample.

4 The greater the variation in gas velocity or dust concentration, the greater the number of sampling points required.

A New Test Code for Gas Producers and Continuous Gas Generators

By Prof. E. A. Allcut, Fellow ASME, Chairman of Committee PTC 16

The first power test code for gas producers was one of the original ten test codes published by the Society in 1915.

A new committee was appointed and a revised code was issued as one of the series of 1923. It was presented to the Society at its Annual Meeting in December, 1924, and was finally approved by the Council in November, 1928.

During the past decade it has become increasingly evident that our limited reserves of fuel must be conserved, as far as possible, by using combustion processes of maximum efficiency. In this regard it is obvious that the most suitable fuel form is gaseous, because gases can be mixed more easily and uniformly than can solids or liquids.

Thus, many combustion processes are logically divisible into two stages, viz.: (*a*) the gasification of the fuel, and (*b*) the formation and burning of a combustible mixture. Gas producers have the advantage of being able to generate large volumes of combustible gases at comparatively low cost but, on the other hand, the heating values of the gases normally produced are comparatively low. Therefore, large pipes or ducts are needed, so that the gases should preferably be burned near the gas generator.

This is a convenient arrangement in the case of some furnaces or gas turbines; also, if a "synthesis gas" is produced, it may form part of a coal-liquifaction process.

Accordingly, a new committee (PTC Committee No. 16) was appointed in 1951 to consider what changes were desirable in the 1928 code and this committee was given the task of drawing up a new test code, which should be better suited to the changed conditions. At the outset, the committee was faced with the difficulty of determining what kinds of plant should be included and, after much debate, it was decided to exclude those producers (notably water-gas generators) that operate intermittently or cyclically. It was felt that, even without these, the code would probably be somewhat voluminous and complicated, in view of the many different kinds of plant and varieties of fuel that must be included. The feasibility of drawing up an alternative short and simple code, or of indicating items that could be abstracted from the main code for that purpose, was debated on several occasions, but the objection was made that each of such tests would be made for some definite purpose, so that a different selection of items would have to be made for different purposes. Accordingly, the committee decided to make the code as comprehensive as possible, leaving to the discretion of the individual manufacturer or individual operator the selection of those items that are appropriate to his particular circumstances.

Another difficulty encountered when using the standard code form was the continual nuisance of referring backward and forward between Section 5 (Computation of Results) and Section 6 (Report of Test Results). Consequently, the committee decided to arrange these two sections side-by-side, so that the corresponding numbers could be arranged opposite each other, thus facilitating cross references. The final draft was completed in November, 1953, and it was then submitted to a selected group in industry for criticism and comment.

Thirty replies were received and the criticisms were divided by the committee into two categories, viz.: (*a*) Matters of principle and (*b*) Matters of detail. Some of the comments cancelled each other, in whole or in part, but wherever possible, those approved by the committee were incorporated in the new code.

This revised test code will be presented through the Board on Codes and Standards to the Council for approval in the near future.

The thanks of the Chairman are due, and are hereby extended, to the members of the technical committee who worked long and hard on this project, and also to the many who contributed by way of review, criticism, or suggestion to the development of the new code. It is

hoped that the profession will find the compilation to be useful.

Reactor Hazards Code Committee Organized

THE Society has accepted administrative sponsorship of ASA Sectional Committee N6, Safety Code for Reactor Hazards. The ASA Planning Committee that laid out a program in nuclear standardization (*Workshop*, April, 1956, MECHANICAL ENGINEERING, p. 399, and November, 1956, MECHANICAL ENGINEERING, p. 1086) suggested the following scope for this committee: Codes and Standards concerned with the hazards involved in the design, location, construction, and operation of nuclear reactors and of potential critical assemblies. Letters of invitation to national organizations have been sent out, and several representatives to the committee have already been appointed.

Revision to Steel Pipe Standard

A REVISION to ASA B36.19-1952, Stainless Steel Pipe, has been submitted to the American Standards Association and is expected to be approved shortly. The proposed revision changes the wall thickness of 12-in. Schedule 5S pipe from 0.165 to 0.156 in. in Table 1.

W. L. Barth Retires

WILLIAM L. BARTH has retired as head of General Motors Engineering Standards and resigned his numerous committee posts on projects sponsored by the Society.

William L. Barth

Mr. Barth was chairman of Sectional Committee B27, Washers and Machine Rings, and chairman of the Executive Committee of Sectional Committee B46, Classification and Designation of Surface Qualities. He was also a member of the following sectional committees: B1, Standardization and Unification of Screw Threads; B5, Small Tools and Machine Tool Elements; and B18, Bolts, Nuts, Rivets, Screws, and Similar Fasteners. In addition he served on many subcommittees under these sectional committees. In 1953, the Society presented him with a testimonial of regard, in appreciation of his "devoted and untiring efforts in the development of standards for screw threads."

Mr. Barth has been placed under special assignment for his company.

F. S. G. Williams Appointed

F. S. G. WILLIAMS has been appointed Chairman of the Special Committee on Nuclear Power of the ASME Boiler and Pressure Vessel Committee. The scope of the Committee coverage of nuclear equipment has been defined and limited to the formulation of rules on materials, design, fabrication, and inspection of pressure-vessel equipment in plants involving nuclear energy as a source of power. The Committee will in no way attempt to cover hazards to health due to nuclear radiation.

The Special Committee has, after considerable study, recommended that the present rules in the ASME Code, Section I, on Power Boilers and in Section VIII, on Unfired Pressure Vessels, as applied to vessels containing lethal substances, are proper for use in nuclear installations with certain modifications which will be covered by Code Cases.

F. S. G. Williams

To date, Code Cases 1224, 1225, 1226, and 1228 covering such modifications have been adopted and published in MECHANICAL ENGINEERING.

William A. Siler

WILLIAM A. SILER, member of the ASME Standardization Committee, died suddenly at his home in Anderson, Ind., Jan. 9, 1957. Mr. Siler was an Associate Member of the Society, from 1921 to 1934, and was a member from 1945 to the present.

Mr. Siler represented the Society on Sectional Committee Y14, Drawing and Drafting Practice, and was also a member of the Y14 Executive Committee. He was a member of B5 Technical Committee 13, Splines and Splined Shafts; B16 Subcommittee 11, Flared Copper Tube Fittings for Refrigeration Service; and B18 Subcommittee 5, Round and Unslotted Head Bolts. In 1954 he was appointed to the Standardization Committee for a five-year term.

Actions of ASME Executive Committee

At a Meeting at Headquarters, Feb. 1, 1957

A MEETING of the Executive Committee of the Council of The American Society of Mechanical Engineers was held in the rooms of the Society, New York, N. Y., on Feb. 1, 1957. There were present: William F. Ryan, Chairman; A. C. Pasini and V. Weaver Smith, of the Committee; J. O. Amstuz, chairman, Finance Committee, E. J. Kates, assistant treasurer; Past-President E. G. Bailey, R. B. Lea and Joseph Pope, directors; C. E. Davies, secretary; O. B. Schier, 2nd, deputy secretary; D. C. A. Bosworth and T. A. Marshall, Jr., assistant secretaries, and Ernest Hartford, consultant.

The following actions are of general interest:

Research Contracts. Four research contracts relating to the activities of the joint ASTM-ASME Committee on Effect

of Temperature on the Properties of Metals have been signed with the Southern Research Institute, University of Michigan Engineering Research Institute, and Battelle Memorial Institute (extension agreements) and a new contract with Battelle. A fifth research contract, with Rensselaer Polytechnic Institute, has also been signed.

Citation. On recommendation of the Oil and Gas Power Division, in which the Board on Honors concurred, it was voted to approve the Oil and Gas Power Division Citation for 1957 for Arthur Stearns Hawks "for his pioneering developments and engineering skill in the design, maintenance, and operational fields of internal-combustion engines and his many contributions to the application of Diesel Engines to marine service, and for the integrity of purpose demonstrated in his engineering career."

Ritual for Engineers. On recommendation of the special Committee on Ritual of Engineers, appointed Sept. 7, 1956, "to consider adoption, possibly by ASME, possibly by EJC, of some ceremony analogous to the Canadian ceremony "The Calling of an Engineer," the question was referred to Engineers Joint Council for consideration.

Certificates of Award. Certificates of Award were granted to Norman W. Andrews, Jr., retiring member of the Safety Division Executive Committee, and to the following retiring chairmen of Sections: Robert C. Wilson, Canton-Alliance-Massillon; J. Richard Cochran, Central Iowa; J. W. Krausser, Cincinnati; J. J. Caldwell, Columbia Basin; H. E. Mayrose, Detroit; J. J. Gallagher, Erie; and H. I. Maxwell, Peninsula Subsection of Virginia Section.

Nuclear Engineering Congresses. Approval was voted of a plan for conducting the 1958 and future Nuclear Congresses prepared by the 1957 Nuclear Congress General Committee and approved by Engineers Joint Council Board of Directors, Jan. 16, 1957, subject to approval by ASCE, ASME, AIEE, AIChE, and American Nuclear Society.

The Institution of Mechanical Engineers. The Secretary of The Institution of Mechanical Engineers reported that a special luncheon had been arranged in London, England, on Jan. 2, 1957, at which the ASME 50-year badge was presented to Gordon M. Campbell, a Member of ASME since 1906.

On recommendation of the Lubrication Division, Donald F. Wilcock was designated ASME representative at the Conference on Lubrication and Wear, London, England, October, 1957.

The Institution of Mechanical Engineers reported that the 1957 James Watt International Medal has been awarded to Dr. Walther Bauersfeld, on recommendation of the Verein deutscher Ingenieure, Germany.

Interchange Arrangements with EUSEC Societies. The Secretary was authorized to carry out, as requested at the EUSEC London Conference, October, 1948, the following procedure with societies which are members of the Conference of Representatives from Engineering Societies of Western Europe and the United States of America (EUSEC).

"Arrangements between the participating societies on a reciprocal basis for the extension of limited privileges of membership to visiting members from other participating societies are desirable, such arrangements being based on bilateral agreements between the participating societies and conforming as far as possible to the following pattern:

(*a*) The visiting members of all grades to be accredited by letter sent by the secretary of one society to the secretary of the other, as well as by similar letter carried by the visiting members;

(*b*) The normal duration of the arrangements for any one visiting member to be six months."

World Power Conference. The report of D. W. R. Morgan, ASME representative on the U. S. National Committee of the World Power Conference, on the meetings of Jan. 16, 1957, was noted and the Executive Committee expressed interest in maintaining close liaison with the World Power Conference. Currently the U. S. National Committee is being supported entirely by trade associations. In order that its work may be more actively carried on and that the professional societies shall have a greater part in this work, Mr. Morgan's report recommended that each of the professional societies make a contribution to the budget of the U. S. National Committee. The Executive Committee referred to the Finance Committee with favorable recommendation an appropriation of $353 as the share of ASME in the support of the U. S. National Committee.

Japan Society of Mechanical Engineers. The greetings and best wishes of ASME will be extended to the Japan Society of Mechanical Engineers on its sixtieth anniversary to be celebrated in June, 1957.

Engineering Societies Personnel Service, Inc. (Agency)

THESE items are from information furnished by the Engineering Societies Personnel Service, Inc., in co-operation with the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to all engineers, members or nonmembers, and is operated on a nonprofit basis.

In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient nonprofit personnel service and are available upon request. This also applies to registrant members whose availability notices appear in these columns. Apply by letter, addressed to the key number indicated, and mail to the New York office.

When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available at a subscription of $3.50 per quarter or $12 per annum for members, $4.50 per quarter for nonmembers, payable in advance.

New York
8 West 40th St.

Chicago
84 East Randolph St.

Detroit
100 Farnsworth Ave.

San Francisco
57 Post St.

Men Available[1]

Chief Engineer, BS, 33; registered; seven years' successful mechanical development, packaging, textile, electronic-equipment experience. Wants to lead development group up to 12 for small O.E.M. complex machinery. Prefers East, not metropolitan. ME-365.

Engineering Manager, Chief; 43; BSME, PE; 18 years in Aircraft, missiles. Creative, sales-conscious. Skilled project engineer in weapons-systems development, structural, electronic, mechanical, and experimental-engineering fields. Capable manager, using advanced techniques in organization, personnel development and relations. Prefers West or North. ME-366.

Executive Engineer, BSCE; 62; 40 years bridge engineer; design and construction, five years; designer, school buildings, ten years; highway engineer, five years; manufacturing engineer, two years; plant engineer, seven years; consulting engineer, seven years. Anywhere United States or possession. ME-367.

Mechanical-Industrial Engineer, BSME, BAChE, 35. Seeks responsible position utilizing business and engineering knowledge. Excellent background in business administration, equipment design, and sales in the aircraft, paper, and air-conditioning industries. Experience includes plant engineering, materials handling

[1] All men listed hold some form of ASME membership.

methods improvement purchasing and marketing problems. Location optional. ME-368.

Application Engineer, BME; 27; five and a half years' varied experience, ordnance and aircraft-equipment development; project engineer for ammunition items, application engineer vehicular mounted electric, pneumatic, air-conditioning units in connection with government contracts, sales proposals; familiar with government specifications. Prefers vicinity of New York City. ME-370.

Department Head—Mechanical-Product Development; 45; over 25 years of machine design and supervision of such work. Main interests in heavy machinery and mechanical and hydraulic controls. Prefers East. ME-371.

Personnel or Plant Engineer, BSME; 25; married; two children; two years in hydraulic servo field which included design, development, and analysis. Experienced in working with analog computers. Would like semi-technical job dealing with people. ME-372.

Chief Engineer, Director of Development, BMME; 47; PE; 22 years mechanical development and engineering administration on complex products for quantity production. Prefers North Jersey or North metropolitan area. ME-373.

Positions Available

Assistant Professor, IE or ME with MSIE and teaching or industrial experience covering methods, time and motion studies, and incentives. $5500 for academic year. N. Y. metropolitan area. W-4223-Rewritten.

Methods Engineer, with education equivalent to four years' engineering college or two years' college plus broad shop training comparable to formal apprenticeship, and about four years' experience, to analyze and set up efficient methods of performing limited variety of mechanical and manual operations in the manufacture of paper containers; develop methods considering manpower, machine capacities, materials, and other related factors on new products, etc. Will work under direct supervision of methods-improvement supervisor. Pa. W-4506.

District Sales Representative, industrial insulation products, 35-45, mechanical or chemical graduate, experience in engineering sales, background in power plant, refinery, or piping-system construction. Knowledge of insulation desirable. Will deal primarily with major accounts in well-established territory, including architectural-engineering firms, boiler manufacturers, large insulation contractors, etc. $10,000. Territory, N. Y. metropolitan area. W-4513.

General Manager-Marketing, 38-45, college graduate, engineering and/or business administration preferred. Must have had sales experience; in addition should have had management experience covering either: (1) all marketing activities in a smaller company or, (2) either field sales or product management in a similar or larger situation. Industrial experience should be in marketing industrial components involving technical design and application. Salary open. New England. W-4523.

Building-Management Engineer, engineering training and at least ten years' experience covering maintenance and operation of large housing projects. Some traveling. PE license desirable. $10,000–$11,000. New York, N. Y. W-4527.

Assistant Chief Mechanical Engineer, 35-40, graduate, administrative and supervisory design experience covering small motors, blowers, or rotating electromechanical devices. $8000, plus substantial profit-sharing bonus. Company pays placement fee. Eastern N. Y. State. W-4528.

Engineers. *(a)* Sales manager for company manufacturing fractional hp motors for special applications. Should have had considerable experience. Some supervision. $10,000–$12,000. Headquarters, Cleveland, Ohio. *(b)* Sales-application representative for company manufacturing fractional hp motors for special applications. $8000–$8500. New York, N. Y. W-4532.

Methods Engineer, 30-38, working experience on both methods and time standards, for central service division of multiplant operations. Some little travel required. $7500–$8000. Company pays placement fee. N. Y. State. W-4533.

Plant Manager, to take entire charge of manufacturing, personnel, production control, etc., of plant in high production, precision, semiheavy metalworking. Must have executive ability. $18,000, plus incentive. New England. W-4536.

Plant Manager, for a sheet metal stamping and roll-forming operation, to take charge of manufacturing activities including all phases of engineering, inspection, production, and production control. $10,000–$12,000. Canada. W-4537.

Teaching Personnel, at least a master's degree, with a doctorate preferred, to teach courses in *(a)* mechanical drawing; *(b)* physics; *(c)* electrical engineering. Salary dependent on experience, age and qualifications. Positions available for fall semester of 1957–1958. New England. W-4541.

Assistant General Plant Superintendent, engineering and/or metallurgy degree, five to ten years' experience in production operations, to control and co-ordinate production activities and supervise the work of various production departments in ore processing plant. $8880–$13,320. Cuba. F-4546.

Manager, New Products Development Department, 32-45, ME degree preferred, approximately ten years spent in engineering pursuits giving a wide range of practical experience in the application of basic engineering principles. Some knowledge of machining and of foundry practices and techniques advantageous. Basic function will be to organize the department, to plant and direct the department in the conception, design, and development of new products that are of a salable nature. Salary open. Vicinity of Newark, N. J. W-4553.

Plant Engineer, 30-40, mechanical or electrical graduate, industrial-building and equipment-metal processing and safety engineering. $8000–$8500. Newark, N. J. area. W-4556.

Technical Editor or Writer for trade publication, graduate mechanical, with three to five years' experience in shop or methods in manufacturing with some writing experience. $7000–$7500. Mass. W-4559.

Engineering Assistant Editor, 25-35, for national publication serving the automation field. Should have practical manufacturing experience, writing ability, and a keen interest in organizing technical information into useful published form. Work includes contacting authors, editing contributed articles, writing feature material of engineering nature. Some travel. Salary open. Headquarters, Ohio. W-4562.

Methods and Production Engineers. *(a)* Methods engineers, 25-35; one for department manager; graduate mechanical, three to five years' experience in small parts fabrication and assembly, for methods analysis in fabrication, assembly and material handling for electronic devices. $8000–$12,000. *(b)* Production-control engineers, 30-54; one for department manager; engineering or business degree, five to ten years' experience in production control, planning, and scheduling, expediting and inventory control. Duties will be areas of experience aforementioned. $8000–$12,000. *(c)* Pilot-line production engineers, 30-45; one for department manager; mechanical degree and/or ten years' experience in line production and some supervisory experience; will co-ordinate all phases of manufacturing of electronic prototype developments to prove the methods, tooling, and general manufacturing ability of all units developed. $8000–$12,000. Conn. W-4564.

Valuation Engineer, graduate civil or mechanical, 28-45, some practical experience in pricing or estimating current costs of utility property; either with utilities, appraisal, or engineering companies, or regulatory commissions. Some construction work and cost accounting knowledge desirable. Will participate in the development of unit costs, such as material, labor, and overheads, applicable to the inventory quantities of natural gas utility properties. To $8400. Some travel. Ohio. W-4565.

Teaching Personnel, Instructors to Professors, rank depending upon degree and experience, for mechanical-engineering department. Courses to be taught are: thermodynamics; heat transfer, fluid mechanics, and laboratories. Should have some teaching and industrial experience. Positions available September, 1957. Midwest. W-4573.

Research Assistants and Teaching Assistants. Opportunities for full or part-time employment on government contracts in mechanics with emphasis on elasticity, vibrations, and electronic instrumentation. Some applied mathematics or electromechanical experience desirable. Part-time teaching assistantships available for undergraduate instruction. Graduate study commensurate with research duties available in engineering mechanics leading to master's degree. To $6000 for full time for 12 months' employment. South. W-4574.

Research Engineer, 23-28, graduate mechanical, emphasis on the dynamic behavior of mechanical components and the analysis and synthesis of mechanical control systems. One to four years' total engineering practice, at least one of which should be in the specialties described under educational requirements. To start, $6000–$8400. R. I. W-4576.

Senior Industrial Engineer, to 45, to go through plant and reorganize as he sees fit; i.e., methods production, plant layout, etc. $10,000–$12,000. Pa. W-4585.

Project Engineer, reinforced plastics, to 45, preferably chemical engineering or chemistry degree but will consider equivalent, with a minimum of one year's experience in some phase of reinforced plastics, such as project engineering, research and development, quality control, trouble shooting, stress analysis. Experience with radomes—honey-comb reinforcement, hand lay-up procedures and low pressure vacuum form molding would be especially helpful. To $8000. Va. W-4593.

Manager of Fluid-Flow and Heat-Transfer Research, advanced ME degree preferred, specialties in heat transfer and fluid flow; five to ten years' experience preferable, at least partly in industrial research or development in these fields. Position will involve the direction of all research in a central laboratory in the fields of fluid flow, heat transfer, combustion, and related areas. $14,000–$17,000, plus all fringe benefits. Vicinity of N. Y. N. Y. W-4595.

Sales Engineer, good technical background and experience in contacting various manufacturers and procurement agencies to secure work for a manufacturing plant. Must be familiar with manufacturing operations and machines used in the manufacture of metal parts. $7500–$10,000. Headquarters, Conn. W-4596.

Manufacturing Engineer, production management, mechanical graduate, to 50, with heavy experience in production, cam layout, and tooling of single-spindle and multispindle automatic screw machines; to participate in creation and management of new metal fabrication division. Will assist in purchasing machinery and equipment, including tooling for new division. To start, $10,000, plus liberal benefits. Newark, N. J., area. W-4598.

Plant Manager, manufacturer of inflatable plastic toys and wading pools, under 45, also pools constructed of aluminum supporting side-wall, tubular steel framework, and vinyl-impregnated nylon liners, the manufacture of which closely resembles type of operation found in garment industry, therefore some experience in the garment industry desirable. Must be experienced in plant management, with a thorough knowledge of piece rate incentive systems, plant layout, plant maintenance, cost control, production planning, and management. Ability to supervise 200 to 250 employees, mostly female, essential. About $15,000 to start. For a period of nine to ten months, in Midwest; then plant plans to move to Mississippi and manager would have to relocate. W-4601.

Instructor of Mechanical Engineering, position available July 1, 1957. Consulting, research and development work is available for extra compensation. $4800–$5400 for nine months' teaching. South. W-4606.

Chief Draftsman, five to ten years' experience in sheet-metal design-drafting with three to five years' experience in a supervisory capacity. Should have a general knowledge of part numbering systems, filing systems, and specific knowledge of drafting procedures as applied to the development in the flat of sheet-metal shapes. Should be familiar with manufacturing processes such as spot welding, arc welding, forming, bending, shearing, penciling, matching, painting, and preparation for painting and general assembly line work and have a specific understanding of tools and dies. Excellent salary with all company benefits. Va. W-4610.

Executive Secretary, 35-40, for state engineering society. Must have state license. $7500–$8500. South. W-4616.

Engineers. *(a)* Mechanical engineer, research and development, graduate mechanical, 40-50, with a rounded background of automation, materials handling, fabrication, manufacturing, and miscellaneous equipment. Should have creative ability, imagination, design, management, and administrative experience. Stress will be put on the number of patents and patents applied for. $12,000–$15,000. *(b)* Mathematician-engineer, under 35, MA degree in mathematics, or bachelor degree in engineering, with strong minor in math; approximately five years' experience with a sales application department of a manufacturer of EDP machines or five years' experience with a governmental

agency in applied math. $9600–$12,000. Western Pa. W-4620.

Dust-Control Engineers, 25–40. *(a)* Application engineer to survey and study industrial-place conditions, prepare recommendations for dust and fume control including systems design, layout and calculation, equipment selection, cost estimates. Establish application-engineering practices on control systems and equipment. Investigate new application fields. Duties will also involve some field work. *(b)* Experimental and test engineer, for laboratory and field experimental and test work on industrial dusts and fumes and control equipment. Experience in air-flow testing, dust sampling and counting, particle-size analysis, and industrial hygiene preferably. Some field test work. Prefer a graduate engineer with laboratory or industrial experience in similar work. $6000–$8000. Md. W-4627.

Dean of Engineering, interested in developing school and has a strong bent toward administration. Salary dependent upon education and experience. South. W-4634.

Engineers. *(a)* Engineer for supervision, BSME, EE, ChE, some production supervisory background. Ground floor opportunity with new subsidiary. $7000–$8000 to start; relocation expenses paid. Ill. *(b)* Market research manager, college degree, statistical orientation. Minimum of three years' experience in sales analysis, sales projections, sales-quota setting, special projects. $7000–$9000 to start. Northern N. J. *(c)* Sales trainee, college degree, sales personality. Approximately one-year training program. Must be willing to relocate. $4200 to start. Headquarters, northern N. J. W-4637.

Project-Design Engineer, 35–55, engineering degree or equivalent education, five to ten years' actual drafting-board design of industrial equipment preferably heavy-rolling mill machinery, should have a working knowledge of steel or nonferrous reduction and mill practices. Will be responsible for the design of improved plant equipment, machinery and methods; perform actual basic design work on assigned projects. Salary open. West Coast. W-4639.

Mechanical Engineer for Mechanical Power-Plant Section, 35–45, BS in ME or better, registered PE preferred, for active participation in the engineering and design of industrial and public utility power plants. Must be able to handle preparation of heat-balance studies, preparation of power studies to obtain maximum economy in production of steam and electricity, be familiar with boiler plant equipment such as large and small intermediate and high-pressure boilers, draft fans, turbine and motor drives, feed-water treating and heating, piping, instrumentation, etc. $9000–$11,000, depending upon experience. Eastern Pa. W-4640.

Industrial Engineer, BSIE degree in industrial engineering, having majored in time study, job evaluation, time and motion, with about one year's experience in the industrial-engineering field. Salary commensurate with experience. Near Poughkeepsie, N. Y. W-4641.

Senior Designers, experience in heating, ventilating, and air conditioning for industrial buildings. $9000–$9500. Company pays placement fee. New York, N. Y. W-4642.

Building-Management Operations and Maintenance Engineer, 35–45, engineering graduate, PE license, and at least ten years' experience, covering office-building operations, planning of new construction and alterations, and estimates and staff administration. $12,000–$13,500. New York, N. Y. W-4649.

Research and Development Engineer, MSME or structural, BSME, to 35; can use recent graduate and train, with a knowledge of applied and fluid mechanics. Will direct experimental work and perform necessary analytical work to provide data by which pumping equipment is designer for a manufacturer of pumps. $7200. Employer will pay placement fee. Ind. C-5928.

Project Engineer, BSME or equivalent, to 35; must know mechanics-math. To take design information from research and development, design pumps for application and services; some board work for manufacturer of pumps. To $7200. Employer will pay placement fee. Ind. C-5927.

Engineering College Teachers: aeronautical engineer; electrical engineer; and mechanical engineer, with advanced degrees and/or experience. Good salary schedule and consulting opportunities; excellent living conditions. Permanent. Southern Calif. S-2618.

Candidates for Membership and Transfer in ASME

The application of each of the candidates listed below is to be voted on after March 25, 1957, provided no objection thereto is made before that date and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

New Applications and ●Transfers

Alabama

Payne, Leo S., Jr., Birmingham

Arkansas

Waldron, Clinton L., El Dorado

California

Baker, Friend F., Jr., Altadena
Beggs, Philip B., San Francisco
Ewing, Harold D., Palo Alto
Harp, Thomas L., San Francisco
Hathway, Charles W., San Jose
McLaughlin, Paul R., Claremont
Parks, Leonard B., San Francisco
●Phillips, James B., Oxnard
Powell, James W., Granada Hills
Richards, Charles M., Mountain View
Roberts, Ernest R., Glendora
Viteri, Fermin, Jr., Sacramento
Zickel, John, San Jose

Colorado

●LaRue, Robert D., Fort Collins

●Transfer to Member or Affiliate

Connecticut

Brownstein, Herman, Waterbury
Gibson, John E., New Haven
Krauss, Paul, Farmington
Skowronski, Edward S., Bridgeport
Whitaker, Walter E., Jr., Niantic

Delaware

Harshman, Roy R., Jr., Wilmington
Schmidt, Edgar H., Wilmington

District of Columbia

Bullington, Edward W., Washington
Wragg, John G. Washington

Florida

Johnson, Edward W., Panama City
Morrison, Howard A., Warrington

Georgia

Sparks, George H., Jr., Augusta

Illinois

Backlund, Robert R., Morton
Coldewey, George, Chicago
Demasy, Joseph, Chicago
Graham, Lois, Chicago
Jacobs, Norman A., Chicago
Johnson, Milton R., Chicago
Kessler, Jack J., Chicago
Lewis, James R., Rock Island
Lich, Richard L., Granite City
Marr, James L., Jr., Forest Park
Mitchell, Gerald T., Wilmette
Newell, Edward D., Evanston
Opsahl, Eugene G., Chicago
●Seymour, Frederick P., Jr., Oak Park
Steidinger, Donald J., Chicago
Uguccioni, Clerio, Chicago
Wiegman, Harold H., River Forest

Indiana

Kouroupis, Basilios D., East Chicago
●Spooner, Albert J., Jr., Indianapolis
Willoughby, Thomas E., Indianapolis

Iowa

Kennedy, Raymond L., Newton
Lindell, John F., Newton
Oleson, Dale G., Newton

Kansas

●Wilson, Joseph R., Merriam

Louisiana

Arbour, Julius B., Baton Rouge
●Groh, George J., New Orleans
●Hall, Christopher H., Baton Rouge

Maryland

Ansted, Kenneth B., Edgewood
Bentz, Marion F., Silver Spring
Brownley, Charles C., Baltimore
Kincaid, Charles V., Baltimore
Utermohle, Charles E., Jr., Baltimore
●Wiles, John H., Hagerstown
Zahn, Albert M., Baltimore

Massachusetts

Antonelli, Mario G., Jr., Fall River
●Bailey, Fred C., Boston
●Black, Robert O., Jr., Boston
Doran, John W., North Andover
Fall, Wilfrid, Worcester
Flint, Alfred W., Grafton
●Gordon, Irving G., Beverly
Graham, John W., Lawrence
Hryckiewicz, Edwin J., Lowell
Korabowski, Adam S., Springfield
●Mooney, David A., Boston
Thursh, Robert E., Concord
*Toesca, Rene A. M., Lynn
Whitney, Donald S., Springfield

Michigan

Avitzur, Betzalel, Ann Arbor
●Bassett, Curtis D., Ypsilanti
Essenburg, Franklin, Ann Arbor
●Kline, John H., Jackson
Lipten, Seymour, Detroit
Schubert, Frank W., St. Clair Shores
Stieler, Carl F., Detroit
Vale, Richard C., Jackson

Minnesota

Frankie, Donald M., Silver Bay
●Hartnett, James P., Minneapolis
Neils, Gerald H., Minneapolis
Solie, Wayne A., St. Paul

Missouri

Diboll, Wallace B., Jr., St. Louis
Plumer, Maurice L., St. Louis

Nebraska

Hall, Arnold R., Nebraska City

New Jersey

●Burton, Charles L., Flemington
●Delistovic, John A., New Monmouth
Gerber, Richard J., West New York
Linke, Carl J., Saddle Brook
Mark, Robert, Newark
Pasquine, Arthur R., Metuchen
Tang, Yu S., Gloucester City

New York

Baldwin, Allen W., Wappingers Falls
Bell, Thomas D., Poughkeepsie
Blumberg, Harry S., New York
●Bollinger, Lawrence R., Schenectady
Boyd, Theodore E., Jr., Mamaroneck
●Cooper, William E., Schenectady
D'Agostino, Robert, New Hyde Park
Del Vecchio, Alfred, New York
Di Marco, C. Andrew, Wappingers Falls
Dombrowski, Briney T., Jr., Seneca Falls
Farris, Raymond O., Franklin Square
●Field, Kenneth A., Wellsville
●Furman, Lloyd W., Jr., Binghamton
Hallatt, William E., Niagara Falls
Kohler, Frederick E., Glen Head
●Lewis, John R., New York
●Mann, John J., Chappaqua
McCalley, Robert B., Jr., Schenectady
●Munn, Robert D., Endicott

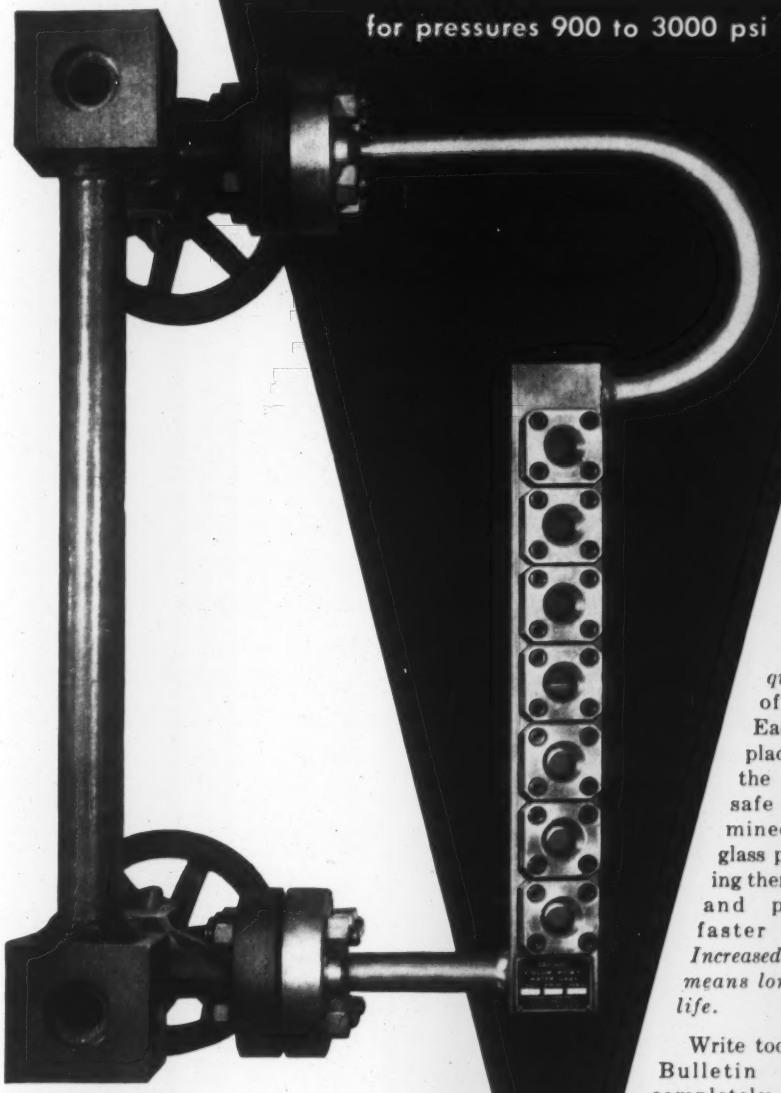
(ASME News continued on page 326)

NEW FROM YARWAY!

COLOR-PORT

BOILER WATER LEVEL GAGE

for pressures 900 to 3000 psi

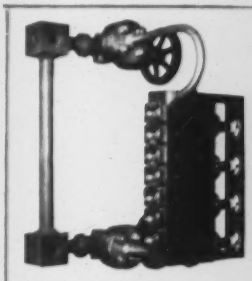


- *two-color readings!*
- *reduced maintenance!*
- *increased availability!*

Now Yarway offers brilliant two-color boiler water level readings, combined with simplicity of gage maintenance and increased availability.

With the new Yarway Color-Port Gage, water space shows green, steam space shows red. A full gage is all green and an empty gage all red.

The Color-Port Gage is *serviced quickly in place* by simple replacement of individual cover-glass assemblies. Each cover assembly is held solidly in place by four socket head capscrews and the "floating assembly" design applies safe predetermined loads on glass ports, reducing thermal shocks, and permitting faster warm-up. *Increased availability means longer service life.*



Side view of Yarway Color-Port Water Level Gage with illuminator, circulating tie-bar and Welbond gage valves.

Write today for new Bulletin WG-1814, completely describing Yarway Color-Port High Pressure Water Level Gages.

YARNALL-WARING COMPANY

108 Mermaid Avenue, Philadelphia 18, Penna.

BRANCH OFFICES IN PRINCIPAL CITIES.

YAR-WAY WATER LEVEL GAGES

MURRAY, DONALD L., New York
MURRAY, RAYMOND E., New Hyde Park
●NOBLES, DOUGLAS G., Horseheads
PERRONE, NICHOLAS, Brooklyn
●PLUNKETT, ROBERT, Schenectady
REY, LUIS A., Olean
RIORDAN, ROBERT M., Poughkeepsie
SHERET, ROBERT G., Rochester
STEILEN, GEORGE C., Flushing
●SYMER, DONALD G., Lancaster
TILLSON, ROBERT P., Scotia
●VAN DERVOR, Richard K., Binghamton
WALKER, JAMES J., Bayside
WEISSGOLD, DAVID J., Brooklyn

North Carolina

CAUBLE, JAMES L., Cliffside
●FLOYD, HORACE G., New Bern
LEMING, HAROLD R., Charlotte

North Dakota

BROWN, CHARLES D., Fargo

Ohio

BAKER, RALPH C., Dayton
●CHUTE, GEORGE M., 3rd, Cincinnati
CLARK, JOHN R., Cleveland
DE GIROLAMO, RAYMOND A., Alliance
KOGER, HERMAN E., Cincinnati
MITCHELL, ANDREW M., Willowick
ROSENFIELD, MYER J., Cincinnati
VANDERZEE, ROBERT S., Akron
VARANELLI, ANDREW D., Cincinnati

Oklahoma

●HAZELRIGG, WAYNE K., Tulsa

Oregon

MOORE, DANIEL J., Portland

Pennsylvania

BAKER, WILLIAM B., Erie
BRIKOWSKI, HAROLD J., Churchtown
●BUFFLAP, CARL A., JR., Willow Grove
CHASEN LAWRENCE I., Philadelphia
COLBERT, JOHN W., Johnstown
EWING, ROY D., Oil City
FICKS, WILLIAM G., Pittsburgh
FIORE, BENJAMIN, Bethlehem
HARRIS, WALTER R., East Pittsburgh
HESSMANN, GEORGE D., Lewistown
HOLL, JOHN W., University Park
●KENNEDY, THOMAS W., Wayne
●KISSICK, JOSEPH, JR., Erie
MELCHER, CONWAY H., Erie
NEWELL, FREDERICK R., Bradford
PROSCINO, VINCENT, Gradyville
PSINAKIS, STEVE E., Reading
●ROSENBERG, RICHARD, Pittsburgh
●WALTHER, GEORGE A., Bridgeville
WILSON, SAMUEL A., SR., Bethlehem
●WISE, DANIEL E., Pittsburgh

Rhode Island

FINDLEY, WILLIAM N., Providence
MURPHY, FRANCIS G., Tiverton
ROESCH, EDGAR B., East Greenwich
SANTOS, STANLEY N., Providence
WILLIAMSON, KENNETH H., Greenville

South Carolina

WRIGHT, JAMES L., Greenwood

Tennessee

●BAKER, PATRICIA B., Nashville
GROSSMAN, ROBERT E., Oak Ridge
TATE, JOHN R., Tullahoma

Texas

●ABBOTT, BRENSON L., Bellaire
BORDELON, HAROLD A., Baytown
CAMPBELL, HUGH T., Baytown
COOPER, GARY, Garland
MCBRIDE, WILLIAM J., La Porte
MEYER, EDWARD F., San Antonio
WHITACRE, JOHN A., JR., Lake Jackson

Virginia

LANCASTER, JOHN B., Norfolk
PELTZ, WALTER L., Hampton
PORTER, DUFF G., RICHMOND

Washington

AUSTIN, GEORGE E., Spokane
CARSON, ARTHUR B., Richland
MCKEE, DOUGLAS W., Richland
RICHARDS, ALFRED C., Richland
RICHESIN, LYNN J., Seattle

West Virginia

●BOECKMANN, ROBERT H., South Charleston

Wisconsin

CROTHERS, JAMES W., Fort Atkinson

Foreign

KELLY, PATRICK J., Dublin, Ireland
KONSTANTINIDIS, GEORGE, Piraeus, Greece
KOOHTOW, WALTER E., Scarborough, Ont., Canada
PALMIERI, EZIO M., Ferrara, Italy
PLOSKEY, EDWARD J., Honolulu, T. H.
SAINT-LAURENT, WILLIE, Montreal, Que., Canada
STEPHENSON, DONALD G., Ottawa, Ont., Canada
TAYLOR, FRANK D., St. Laurent, Que., Canada
VRANA, JOHN C., Montreal, Que., Canada

Transfers from Student Member to Associate Member, Class of 1968.....50

Obituaries

Herbert Burdick (1883–1956?), whose death was recently reported to the Society, was a design and development engineer, and head of his own firm, Bloomfield, N. J. Born, Nyack, N. Y., Feb. 13, 1883. Parents, William H. and Scedenia (Bedell) Burdick. Education, high-school graduate; ICS. He held patents pertaining to adding machines, code devices, relays, and so on. Assoc.Mem. ASME, 1917; Mem. ASME, 1923. Served the Society on Executive Committee of the Hartford Section.

Major Lester Durand Gardner (1876–1956), aeronautical executive and a founder of the Institute of the Aeronautical Sciences, New York, N. Y., died Nov. 23, 1956. Born, New York, N. Y., Aug. 7, 1876. Parents, Harry and Frances (Scott) Gardner. Education, SB, Massachusetts Institute of Technology, 1898; studied administrative law at Columbia University, 1900; hon. LLD, Polytechnic Institute of Brooklyn, 1943. Married Margaret Kettle, 1913. Assoc.Mem. ASME, 1922. In 1915 Mr. Gardner took a responsible job on an aviation magazine that so stimulated his interest it led to establishment of one of his own the next year. Further stimulation was provided by a year's service in the Army during which time he helped organize a number of aeronautical squadrons in this country for overseas service. In 1918 he attained the rank of major. He was also the founder in 1916 of *Aviation Magazine*, now the McGraw-Hill Publishing Company's *Aviation Week*. In 1926 Mr. Gardner sold his interests in his publishing business, which later became the Gardner Publishing Company, and devoted his time to a study of European airline development. In 1927 President Calvin Coolidge appointed Mr. Gardner United States delegate to the Fourth International Aviation Congress in Rome. The next year he was United States delegate to the International Conference on Civil Aeronautics in Washington, D. C. In the same year he became president of Aeronautical Industries, Inc., an investment trust, and was elected president of the Aeronautical Chamber of Commerce of America. Mr. Gardner and several colleagues founded the Institute of the Aeronautical Sciences in 1932. He became its secretary, later rising to higher posts, including president of the Aeronautical Archives, established by the organization in 1939. For his efforts in founding the Institute he received the Daniel Guggenheim Medal in 1947, one of aviation's highest awards. In the years preceding World War I, Mr. Gardner's scientific bent led him to explore the medical and commercial possibilities of radium. He tested its application in paint, ink, and medicine. He visited the Curies in Paris to learn more about the substance.

William Wallace Hanscom (1868–1956), independent consulting engineer, San Francisco, Calif., died Nov. 9, 1956. Born, San Francisco, Calif., Dec. 1868. Parents, William W. and Abbie P. Hanscom. Education, high-school graduate. Married Susie L. Richards, 1908; two sons, William W., Jr., and Russell C. Invented and patented lead storage-battery elements for which he received a Gold Medal in London Agricultural Exposition c. 1900; author of several technical articles published in trade journals. Mem. ASME, 1913. Served the Society as Section chairman, committee work on State Accident Codes, meetings, papers, and so on.

Robert Siegfried Hantsch, Lieutenant, USAF (1933–1956), died Oct. 26, 1956, in an airplane crash. Born, White Plains, N. Y., Feb. 11, 1933. Parents, Herman and Martha Hantsch. Education, Augusta Military Academy, 1950; BS(ME), Stevens Institute of Technology, 1954. Married Ingrid Rodal, 1954. Assoc. Mem. ASME, 1954.

Horace Sinclair Hunt (1883–1956), president, Fargo Engineering Co., Jackson, Mich. died Nov. 10, 1956. Born Jackson, Mich., Oct. 10, 1883. Parents, Charles P. and Anna (Sinclair) Hunt. Education, BS(ME) and BS(CE), Michigan Agricultural College, 1905. Married Mary Cecile Alden, 1912. Mem. ASME, 1919. During World War I, he was Director of Conservation for Michigan under the U. S. Fuel Administration. In addition to having been connected with the design and construction of about 40 hydroelectric projects he had been consulting engineer on dams and hydroelectric plants for the Lower Colorado River Authority, Texas, the Central Nebraska Public Power and Irrigation District, the Vicksburg and Tulsa District of the Corps of Engineers, and has acted as consultant to the TVA on special valuation matters. Survived by wife and three children, Horace S., Jr., Jackson, Mich.; Charles A., North Plainfield, N. J.; and Mrs. Florence E. Peterson, Jackson, Mich.

Waldemar Bernhard Kaempffert (1887–1956), science editor, *The New York Times*, died Nov. 27, 1956. Born, New York, N. Y., Sept. 23, 1887. Parents, Bernhard and Juliette Kaempffert. Education, BS, College of the City of New York, 1897; LLB, New York University, 1904; hon. DS, Clarkson Polytechnic Institute, 1939. Married, Carolyn Lydia Yeaton, 1911 (died 1933). He was admitted to the New York bar in 1903; registered as a patent attorney. In 1897, Mr. Kaempffert obtained a job as an assistant editor of *The Scientific American;* in 1911 he was named managing editor of that magazine. Four years later he joined *Popular Science Monthly* as editor and remained in that position until 1920. He became science editor of *The New York Times*, writing a weekly column on current research, occasional editorials on scientific subjects, and sometimes covering conventions of scientists and other news events in his field. As a result of his world-wide reputation as a science editor he was invited to become director of the Chicago Museum of Science and Industry founded by Julius Rosenwald. At the time the largest technical museum in this country, it was modeled after the Science Museum of South Kensington, the Conservatoire des Arts et Metiers, and the Deutsches Museum of Munich, with over 400,000 sq ft of science and engineering exhibits, most of them in operation. Except for three years spent in this post his work at *The Times* occupied him until his death. As one of the earliest "science editors" in journalism his specialty was explaining the technical discoveries of scientists to the layman in popular language. Thousands of his articles informed the average reader of the ever-increasing flow of new-found facts. His subject was as wide as nature itself, and, though he often dramatized science he never sensationalized. In his speculations on matters ranging from a rocket trip to Mars to self-hypnosis, he exhibited a lucid style, without bewildering the reader by talking over his head or patronizing him by talking down. Mr. Kaempffert was elected to Phi Beta Kappa upon his graduation from City College. In 1954 he became the first science editor to receive the Kalinga Prize offered by UNESCO. He was nominated for the award by the British Association of Science Writers, which cited him for contributions to the public understanding of science. In the same year he accepted for *The Times* a special award of the Albert and Mary Lasker Foundation. It credited him with having "shaped profoundly his newspaper's contribution to medical reporting in the public interest." Mem. ASME, 1930; Fellow ASME, 1956. He wrote articles for other publications than *The Times* on many occasions. He was the author of six books on various aspects of science and served as editor of half a dozen other popularized volumes, some for children.

Charles K. Longenecker (1867–1956?), whose death was recently reported to the Society, was president of Chas. Longenecker & Co., New York, N. Y. He had made his home at Strath Haven Inn, Swarthmore, Pa. Born, Shamokin, Pa., Dec. 26, 1867. Education, graduate, common schools of Lancaster, Pa.; two years private instruction. Mem. ASME, 1892.

William J. Murphy (1888–1956), construction superintendent, Public Service Electric & Gas Co., died March 22, 1956, Glen Ridge, N. J. Born, Brooklyn, N. Y., Nov. 9, 1888. Parents, Matthew W. and Mary F. (Cochran) Murphy. Education, ME, Cooper Union, New York, N. Y. Married Elizabeth G. MacKeugh, 1913. Survived by wife and son, Matthew W., Metedeconk, N. J. Mem. ASME, 1927.

(*ASME News continued on page 328*)

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Keep Your ASME Records Up to Date

ASME Secretary's office in New York depends on a master membership file to maintain contact with individual members. This file is referred to dozens of times every day as a source of information important to the Society and to the members involved. All other Society records and files are kept up to date by incorporating in them changes made in the master file.

From the master file are made the lists of members registered in the Professional Divisions. Many Divisions issue newsletters, notices of meetings, and other materials of specific interest to persons registered in these Divisions. If you wish to receive such information, you should be registered in the Division (no more than three) in which you are interested. Your membership card bears key letters, below the designation of your grade of membership and year of election, which indicate the Divisions in which you are registered.

Consult the form on this page for the meaning of the letters. If you wish to change the Divisions in which you are registered, please notify the Secretary's office.

It is important to you and to the Society to be sure that your latest mailing address, business connection, and Professional Divisions enrollment are correct. Please check whether you wish mail sent to home or office address.

Please complete the form below and mail it to: ASME, 29 West 39th Street, New York 18, N. Y.

Please Print

ASME Master-File Information

Date

LAST NAME | FIRST NAME | MIDDLE NAME

POSITION TITLE
e.g., Design Engineer, Supt. of Construction, Manager in Charge of Sales, etc.

NATURE OF WORK DONE

NAME OF EMPLOYER (Give complete name in full)

Division, if any

* ☐

EMPLOYER'S ADDRESS | City | Zone | State

ACTIVITY, PRODUCT, or SERVICE OF EMPLOYER; e.g., Turbine Mfrs., Management Consultants, Oil Refinery Contractors, Mfr's. Representative, etc.

* ☐

HOME ADDRESS | City | Zone | State

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Address changes effective when received prior to:

I subscribe to

☐ Mechanical Engineering	10th of preceding month
☐ Transactions of the ASME	20th of preceding month
☐ *Journal of Applied Mechanics*	20th of preceding month
☐ *Applied Mechanics Reviews*	1st of preceding month

Please register me in three Professional Divisions as checked:

☐ A—Aviation	☐ J—Metals Engineering	☐ R—Railroad
☐ B—Applied Mechanics	☐ K—Heat Transfer	☐ S—Power
☐ C—Management	☐ L—Process Industries	☐ T—Textile
☐ D—Materials Handling	☐ M—Production Engineering	☐ V—Gas Turbine Power
☐ E—Oil and Gas Power	☐ N—Machine Design	☐ W—Wood Industries
☐ F—Fuels	☐ O—Lubrication	☐ Y—Rubber and Plastics
☐ G—Safety	☐ P—Petroleum	☐ Z—Instruments and Regulators
☐ H—Hydraulics	☐ Q—Nuclear Engineering	

Percy Paul Pratt (1896–1956), vice-president, manufacturing and engineering department, General Foods Corp., died April 4, 1956. Born, Athens (Calhoun), Mich., Oct. 30, 1896. Education, BS, Massachusetts Institute of Technology, 1923. A specialist in engineering economics—plant process design and location, Mr. Pratt was employed by the Postum Company and later the General Foods Corporation. He served as a lieutenant colonel in the United States Army during World War II. He was the author of a paper on materials handling presented before the 1928 ASME Fall Meeting. Mem. ASME, 1946.

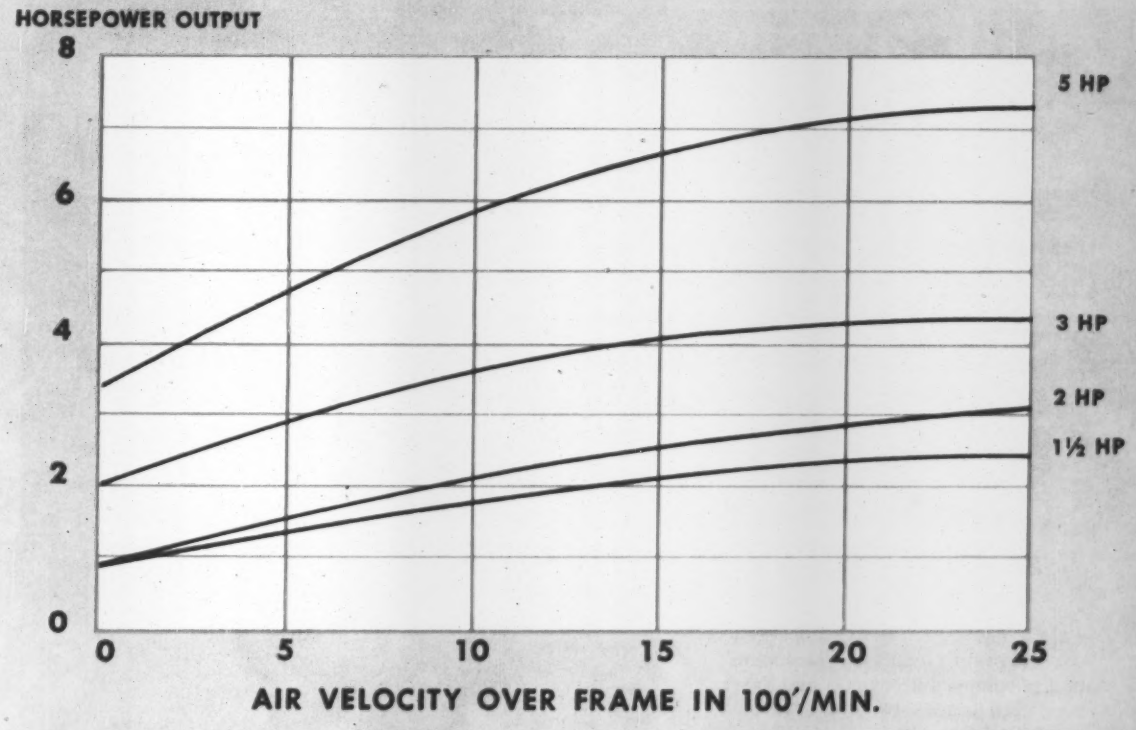
William Clarence Rahe (1925–1956), plant superintendent, American Metal Craft Co., Waterville, Ohio, died in an automobile accident Nov. 12, 1956. Born, Toledo, Ohio, Sept. 13, 1925. Parents, Clarence F. and Gertrude (Blum) Rahe. Education, BS(ME), University of Illinois, 1946; MS, University of Michigan, 1950. Married Mary A. Meyer, 1950. Assoc. Mem. ASME, 1949. Survived by wife and three children, Pamela Sue, Rodney William, and Scott Michael.

Halver Rufus Straight (1884–1956), a specialist in the ceramic industry, Adel, Iowa, died Sept. 28, 1956. Born, El Paso, Ill., Aug. 24, 1884. Education, ME, University of Illinois, 1907. He was the author of many articles published by the American Ceramic Society and the American Society of Agricultural Engineers. He held at least 82 U. S. patents, largely in connection with the clay-products industry. Mem. ASME, 1946.

Ernest Szekely (1888–1956), heating, ventilating, and air-conditioning specialist, Wauwatosa, Wis., died Nov. 29, 1956. Born, Debrecen, Hungary, July 24, 1888. Parents, Emil and Cecily (Morvay) Szekely. Education, ME, University of Budapest, 1910. Naturalized U.S. citizen. Mem. ASME, 1944. Married Sari Dobo. He was president of the Bayley Blowing Co., Milwaukee, Wis. Mem. ASME, 1944. Survived by wife and a son, George Emery Szekely, Milwaukee, Wis.

George Alfred Watts (1906–1956?), superintendent of products development, The Babcock & Wilcox Research Center, Alliance, Ohio, died recently, according to a report received by the Society. Born, Jonesboro, La., Aug. 30, 1906. Education, BS(ME), Louisiana Polytechnic Institute, 1929. He was associated with The Babcock & Wilcox Company from 1930 until his death. He was the co-inventor of the cyclone furnace and held six patents. He was the author of "Multi-Fuel Firing Cyclone Furnaces," delivered at the 1956 ASME Semi-Annual Meeting in Cleveland, Ohio. Mem. ASME, 1955.

Major General Charles Macon Wesson, USA (1878–1956), retired Chief of Ordnance, Washington, D. C., died Nov. 24, 1956. Born, St. Louis, Mo., July 23, 1878. Education, United States Military Academy, 1900; graduated from Ordnance School of Technology, 1911; Army War College, 1925. General Wesson, fifteenth Chief of Ordnance of the Army of the United States, had a distinguished military career. Following his graduation from the U. S. Military Academy he served for two years with the artillery and cavalry. He returned to the Academy as an instructor in the department of philosophy for four years. During World War I, after rebuilding the Watertown Arsenal, he served as Commanding Officer of the Ordnance Repair Shops at Mehun-sur-Yevre and later was in charge of ordnance construction and maintenance of the American Expeditionary Force. For exceptionally meritorious and distinguished services in these endeavors he was awarded the Distinguished Service Medal. In 1925 he was assigned to duty as Commanding Officer and also constructing quartermaster of the Aberdeen Proving Ground, Md. At the end of this assignment, in 1929, he became assistant military attache at the U. S. Embassy in London. At the time of his appointment to the position of Chief of Ordnance, in 1938, he was completing a second tour of duty at Aberdeen Proving Ground. General Wesson was awarded an oak leaf cluster to the Distinguished Service Medal for his efforts in the largest arms production program in the history of the United States. He directed the Army phase of the program, utilizing research and production facilities of American industry to maximum effect. In addition he was awarded the General C. C. Williams Gold Medal of the American Ordnance Association. He was later awarded a second oak leaf cluster to the Distinguished Service Medal for service with the Lend-Lease administration. In 1941 General Wesson was made an Hon. Mem. ASME. He is survived by his wife, Mrs. Virginia R. Wesson, and two daughters, Mrs. Gordon M. Wells and Mrs. Anne W. Stone.



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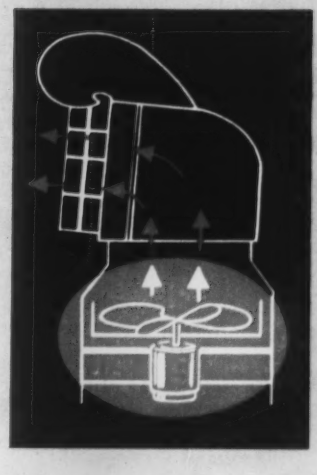
Reliance has developed a new line of totally-enclosed motors for fan service. These motors produce more horsepower when mounted in the air stream of the driven fan. Reliance Air-Over Motors will develop as much as 50% more than rated horsepower by utilizing the cooling effect of the fan's air flow.

These new Reliance Motors will save you money. By purchasing a lower horsepower rating you can save more than 15% and still meet job specifications.

Reliance Air-Over Motors are available from ½ through 40 horsepower—720, 900, 1200, 1800, or 3600 rpm. Common horsepower ratings are available from stock.

B-1547



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⅛ in. to 3 in.

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Jenkins Bros. introduced the first renewable composition disc Globe . . . is still the only manufacturer of both valves *and* discs.

Fig. 106-A not only looks better — it proves out better in performance. In any comparison, its long-life, low-upkeep record has always set the standard. That is the true measure of valve cost — and it is the reason why industry's shrewdest buyers will settle for nothing less than Fig. 106-A quality.

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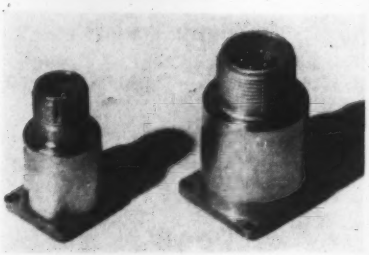
Available literature or information may be secured by writing direct to the manufacturer. Please mention MECHANICAL ENGINEERING.

NEW EQUIPMENT



Indicator Switch

What is claimed as a "foolproof" device that signals when a valve has completed its closing or opening cycle has been developed for use in aircraft and guided missiles by Bridgeport Thermostat Div., Robertshaw-Fulton Controls Co., Milford, Conn.

The new "Capswitch" position indicator is being used on propellant valves for malfunction analysis by a leading manufacturer of rocket engines, according to the company. It is said to be adaptable to any type of control where repeatability within + .001 in. is desired.

Two models of the position indicator are offered. Both are small, lightweight, completely sealed in epoxy resins, and the entire mechanism is encased in a steel shell.

The indicator is mechanically actuated by a sealed plunger, which is depressed by the valve stem, thus closing and/or opening control circuits.

One model, designated the 65M41, is of the SPDT type and weighs .095 lb. The 65M83 model is a DPDT type weighing .19 lb.

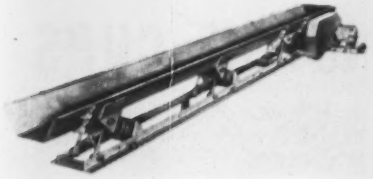
Thrust Bearing

A double-acting aligning thrust bearing designed for the most severe conditions where potential misalignment and heavy but intermittent thrust loads from either direction are present, is announced by Rollway Bearing Co., 541 Seymour St., Syracuse, N. Y.

In assembly for steel forming passes, the special bearing consists of two center thrust plates, two roller assemblies, a left-hand convex-curved thrust plate with concave-curved aligning plate, a right-hand concave-curved thrust plate with convex-curved aligning plate, and an inner spacer sleeve.

One-inch diameter rollers are staggered to insure even wear distribution: three $^1/_2$-in. long rollers in each of ten slots, and two $^3/_4$-in. long rollers in ten alternating slots. Bearing thrust capacity, at 100 rpm, is 114,275 lb.

This Type DAT thrust bearing is used in conjunction with specially designed aligning radial roller bearing. The bearing's straight inner race is separable with roller assembly self-contained in outer race. Outside diameter of double-flanged outer race is concave for alignment with convex surface of aligning ring. Capacity of special MUC type radial bearing is 278,800 lb at 100 rpm.



Oscillating Conveyor

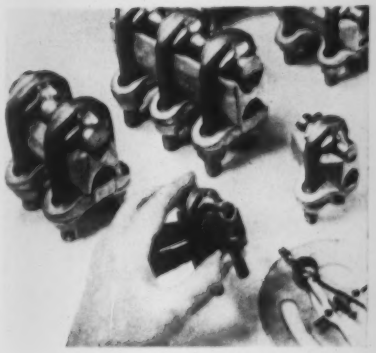
What is described as the newest design in oscillating conveyors, designated Coilmount, has been introduced by Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill.

The unit is especially engineered for applications in the intermediate ranges and capacities to augment and complement the light and heavy ranges of the firm's Flexmount and Torqmount conveyors for bulk materials handling, it is stated.

The company says the new conveyors are similar to others in its line, except that the trough in which material is conveyed is supported by cast aluminum rocker legs and coil springs.

Motion is imparted to material carried in trough by means of a constant-stroke eccentric drive that produces an upward and forward oscillating movement resulting in a gentle, continuous forwarding of materials regardless of overloads or surges. It is available in fully assembled sections of 5 to 10 ft lengths, in trough widths of 10-and 20 in., in 10 gage or $^3/_{16}$ in. trough thickness. Sections can be assembled in lengths up to 100 ft.

According to the company, coil springs absorb nearly all inertia forces through natural frequency principles and provide maximum drive reserve for overcoming surge loads.



Electrical Connectors

A new series of electrical connectors has been developed by Aluminum Company of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa. The units are said to make possible a major reduction of conductor clamp inventories. Heavy-duty U-bolt clamps, employing universal, parallel spacer grooves, now can be used on a wide range of cable sizes.

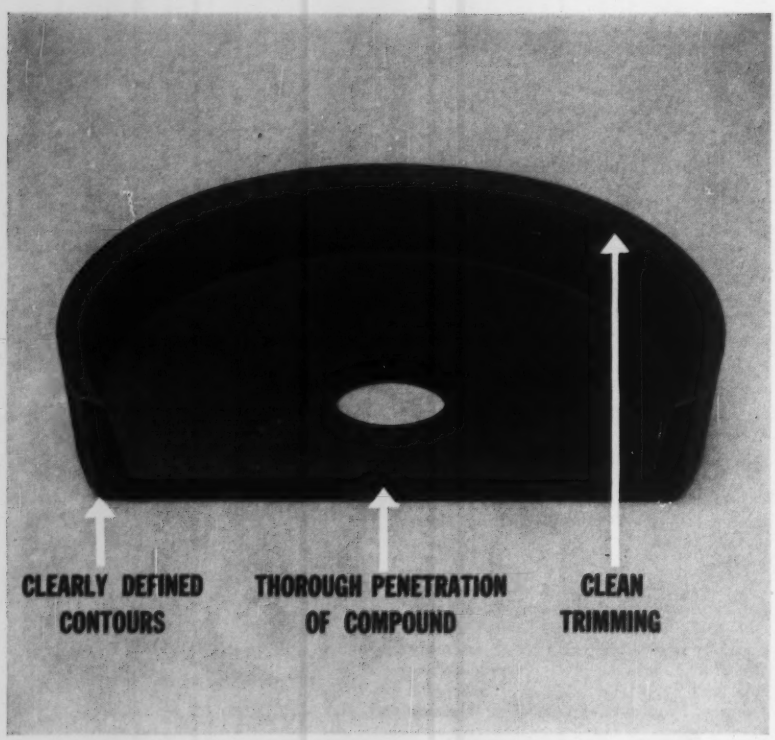
The six clamps, designated 580 Series, can be used on ACSR from No. 2 to 715.5 MCM, and will also handle sizes No. 2 to 800 MCM stranded aluminum conductor. All proportions—length of clamps, number of bolts, bolt sizes—are engineered for the range of conductor size to be accommodated and the job to be done, the company reports. The U-bolt portion, flattened to reduce bulk, provides wrap-around strength and even pressure distribution.

In laboratory tests the clamps have undergone a thousand heat cycles using various conductor combinations, the firm states. Test currents produced conductor temperatures in 200 F, with no significant change in connection resistance.

Compressor Lubricant

Pydraul AC, a fire and explosion resistant fluid developed by Monsanto Chemical Co., 800 N. 12th Blvd., St. Louis, Mo., specifically as a lubricant for air compressors, is the subject of a technical bulletin published recently by the company.

Use of the fire-resistant fluid in place of petroleum oil greatly reduces hazards of air compressor explosions and receiver fires, the bulletin states. Pydraul AC also is reported to minimize the formation of carbon deposits on exhaust valves and air system components.



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R/M FABRIC PISTON CUPS

Designers of hydraulic and pneumatic equipment like these quality features built into R/M Fabric Piston Cups, because they mean extra performance and longer wear:

1. Precision molding—Note the clear definition of contours, smooth surfaces, clean trimming—all evidence of top-flight molding practice.

2. Superior impregnation—Cut an R/M Fabric Piston Cup apart, and you will see how R/M's special method gives deeper, more thorough penetration of the compound into the fabric. This keeps wicking action from destroying the cup internally and gives greater resistance to ply delamination.

3. Controlled tolerances—Careful quality control insures dimensional uniformity, consistent hardness, and strict adherence to industry standard sizes.

R/M Fabric Piston Cups are available to fit cylinders from ½ to 12 in. in diameter. Types are furnished in varying degrees of hardness for pressures up to 1500 psi and in different compounds to meet specific operating conditions.

R/M's complete line of mechanical packings includes: Vee-Flex Packings, Vee-Square Packings, Homogenous Vee-Rings, Fabric Piston Cups

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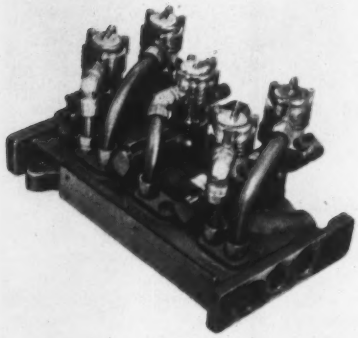
KEEP INFORMED — NEW EQUIPMENT · BUSINESS NOTES · LATEST CATALOGS

Aircraft Lock Bolts

Standard Pressed Steel Co., Jenkintown, Pa., has been licensed by Huck Mfg. Co., Detroit, Mich., to make Huck's proprietary lock bolts out of Titanium, only 57 per cent as heavy as alloy steel.

The titanium bolts will be as strong as their steel counterparts, the firm reports. They will permit weight savings in aircraft through size-for-size substitution of titanium for steel lock bolts.

The lock bolts made of alloy steel are used widely in the air-frame industry for critical, structural and skin panel assemblies. They will be produced in tension-pull, shear-pull and stump types, in sizes ranging from No. 10 to $^{3}/_{8}$-in. diam.



Valve Manifold

A new manifold designed to afford economical and efficient multiple mounting of the firm's 2, 3 or 4-way valves in any desired combination, is announced by Valvair Corp., 454 Morgan Ave., Akron 11, Ohio.

Available in 2 and 3 station types, the new cast aluminum manifold has full length inlet and exhaust ports, both 1 in. NPT, common to all valve stations. Electrical wiring is run through a $1^{1}/_{4}$-in. NPT conduit passage, with one access cover for all stations to simplify wiring. Pilot solenoids leads are enclosed in dirt and moisture-proof flexible conduit. The manifolds are designed with side or bottom cylinder porting to facilitate piping. Holes for mounting the manifold and valve assembly are also provided.

According to the manufacturer, the new manifold can be adapted to any type of control valve application. Combinations of single or double solenoid valves can be mounted at any station on the manifold. The 2, 3 and 4-way valves can be used in any combination. Remote operated, speed controlled and oil pilot valves also are suitable for installation.

To afford uniform mounting of 2, 3, 4, 5, 6 or more valves, manifolds can be ganged by bolting the assemblies together, end-to-end. O-rings seal inlet, outlet and wiring ports.

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

NPT threading of ports simplifies connection to supply and plugging of terminal ends.

Use of the new manifolds is said to reduce piping time and material costs at machine assembly. Equally spaced cylinder connections will improve appearance of complex piping, the manufacturer claims. In addition, the manifold permits the use of a cost-reducing centralized lubricating and filtering air supply system.

The new manifold is offered in 2 and 3 station types with $^3/_8$ or $^1/_2$ in. NPT cylinder ports. Kits of O-rings and through-bolts, for ganging manifolds end-to-end, are also available.

Motive Power Battery

What is described as a basic scientific development that makes possible new capacity standards for storage batteries used to power electric industrial trucks has been announced by Exide Industrial Div. Electric Storage Battery Co., Dept. TG, Box 8109, Philadelphia 1, Pa.

It is accomplished through the use of a new type of armored porous tubing to encase the grid spines and active material of the positive battery plates, to concentrate more power into the same battery-cube space.

The tubing is described as highly permeable to the diffusion of electrolyte and the passage of current. According to the company, it acts like a highly efficient cigaret filter, facilitating the electrochemical action. The battery with the new tubing is said to be particularly effective at high discharge rates.

The tubing prevents practically any loss or shedding of active material, the firm states. Although the porosity is extremely high, the minute openings are such that virtually no particles can work their way through. It is impervious to electrochemical action within the battery, and is highly resistant to the attack of acid.

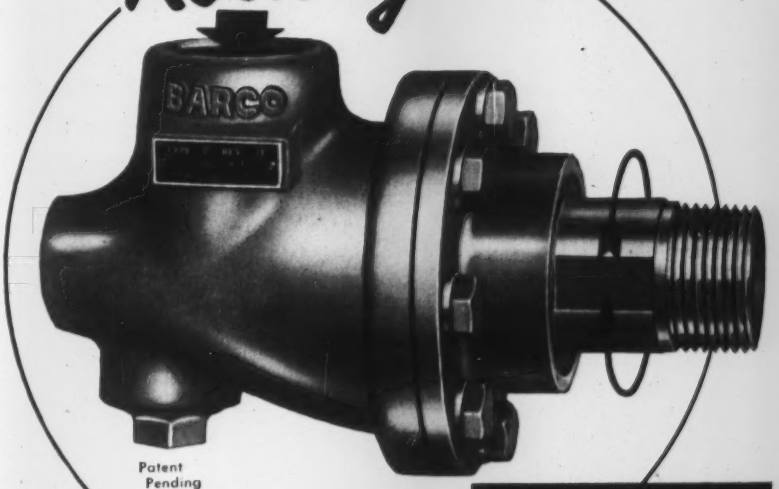
Batteries incorporating the new principle are available in finished steel trays in eleven sizes, with from 11 to 33 plates, capacities ranging from 360 to 1152 amp-hr at the 6-hr discharge rate.

100 KV Test Set

Peschel Electronics Inc., 19 Garden St., New Rochelle, N. Y., announces a 100 KV d-c test for insulation testing of samples, or full reel tank testing.

According to the company, the unit offers a preferred method of checking the insulation of cables and it meets new IPCEA standards as well as MIL, JAN and ASTM specifications. Features incorporated in the unit include 0-100 KV voltage output, adequate capacity for rapidly charging full reels, automatic output shorting, external interlock provision, KV meter and current meter for determining leakage resistance, overcurrent trip-out to de-energize HV, Dual range meters.

NOW-A Better Rotary Joint!



Patent Pending

SIZES
½" ¾" 1" 1¼"
1½" 2" 2½" 3"

NEW BARCO TYPE C Rotary Joint

Announcing...

It's new! It's simple! It's versatile! And for countless applications, Barco's new Type C Rotary Joint will give you the best operating records you've ever had.

FOR ALL SERVICES—One basic style of revolving joint for single flow or syphon flow ... one basic seal for steam, air, water, oil, gas — *or alternating hot and cold!* For temperatures to 450°F. Special to 500°F.

NO LUBRICATION NEEDED — Bearings and seal self-lubricating. Seal self-adjusting for wear. Long life without repairs or maintenance.

LOW TORQUE — Low starting and running torque*. Saves power. Suitable for any ordinary speed. To 200 psi, steam, or 400 psi, hydraulic.

COMPACT, SIMPLE — Malleable iron body; heat treated steel shaft; R.H. or L.H. thread. Eight sizes, ½" to 3".

**Typical example: 12 in. lbs. starting torque for 1" Type C on 100 psi water. Rotating torque, same.*

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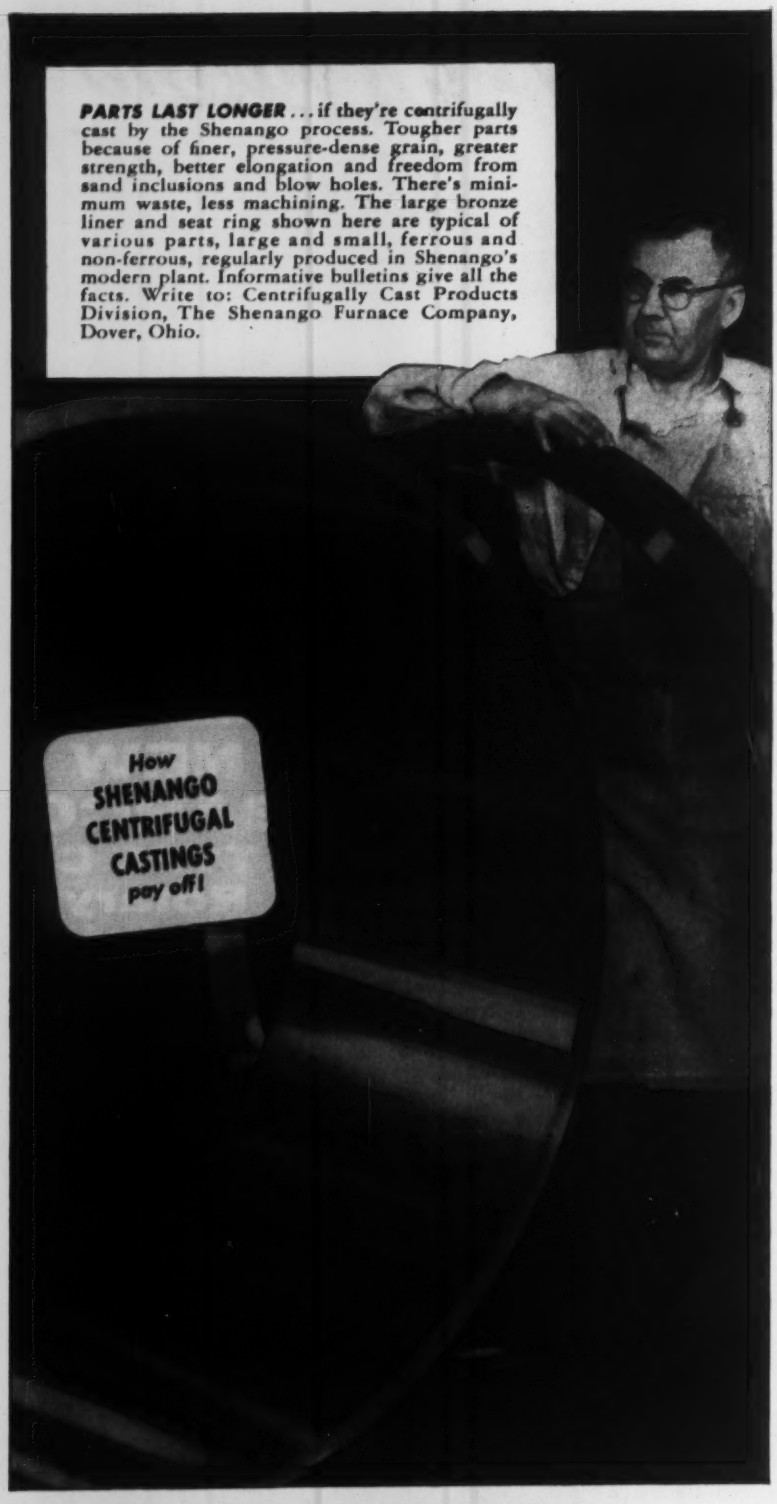
PARTS LAST LONGER . . . if they're centrifugally cast by the Shenango process. Tougher parts because of finer, pressure-dense grain, greater strength, better elongation and freedom from sand inclusions and blow holes. There's minimum waste, less machining. The large bronze liner and seat ring shown here are typical of various parts, large and small, ferrous and non-ferrous, regularly produced in Shenango's modern plant. Informative bulletins give all the facts. Write to: Centrifugally Cast Products Division, The Shenango Furnace Company, Dover, Ohio.
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NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Plastic Pipe Cement

A paper-thin layer of plastic on a section of the inside wall of a new pipe fitting has been developed by United States Rubber Co., New York 20, N. Y., as a means of doing away with the problem of leaks at joints in cemented, or solvent-welded, plastic pipe installations.

The plastic layer, only a few thousandths of an inch thick, makes the inner half of the fitting slightly smaller than the outside diameter of the pipe it is used to join, the firm states. A light coat of solvent base cement on the inside of the fitting, and on the pipe end, softens the plastic layer so the pipe can be pushed snugly into place.

High contact pressure between pipe and fitting causes a positive weld, according to the company. The weld is said to be strong enough within seconds for ordinary handling, and in about two hours the solvent-softened plastic in the weld area is hardened so the joint is as strong as the pipe itself.

The new fitting also has a flared entrance, leading to the narrow interior section, so pipe can be inserted quickly and easily. This flared opening also aligns the pipe automatically for welding.

Small Clinch Nut

Grip Nut Co., South Whitley, Ind., announces a new, smaller size clinch nut, Nos. 4, 6 and 8, with and without the firm's Gripco locking feature.

Formerly the clinch nuts were made only in sizes from No. 10 through $^{5}/_{8}$ in. In addition, the dimensions of the No. 10 size and the $^{1}/_{4}$ in. have been changed to smaller across flats and also smaller across flats clinching collars, the company reports.

Electronic Counter

Performance Measurements Co., 15301 W. McNichols Rd., Detroit 35, Mich., announces a 7-lb portable electronic counter which features a combination of plug-in electronic decade and five-digit mechanical register. The design consists of an input amplifier, pulse shaper, plug-in electronic decade unit and register.

Capable of counting rates up to 12,000 counts per minute (200 per sec) the unit is said to be suited for a variety of testing and measurement problems in industry. According to the company, it meets shop or lab counting needs which are beyond the speed of ordinary electro-mechanical counters, but do not require the counting speed or elaborateness of multi-decade electronic counters.

The counter will respond to electrical pulses of 2.5 v peak, such as derived from a photocell or magnetic pickup, or will respond to ordinary contact closure. Count capacity is 999,999 counts, with an accuracy of ±one count. It operates on 105–125 VAC, and has 90 v d-c accessory power available for operation of photocells, etc.

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NEW EQUIPMENT
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Pressure Regulator

A new type of line pressure regulator said to incorporate many advantages found only on more expensive types has been announced by Hoke, Inc., 211 S. Dean St., Englewood, N.J.

Called the 660 series, the new regulator has, according to the company, a built-in pressure relief mechanism that automatically relieves a build-up of back pressure on the delivery side that exceeds the set delivery pressure.

The complete series consists of four styles, delivery pressure ranges of 0–40 psi or 0–150 psi and flow rates up to 2500 cfh. All styles have an O-ring seat designed to provide absolute shut-off and are offered in a choice of either in line or angle pattern inlet-to-outlet connections.

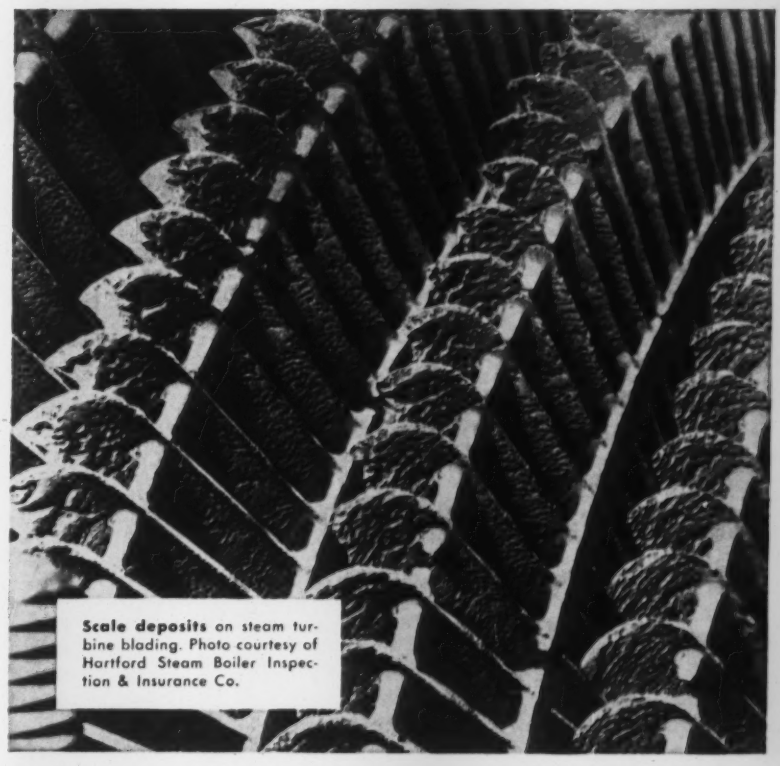
Gear Speeder

Easier and truer noise inspection of larger size mating gears is said to be made possible with a modified standard gear speeder from Michigan Tool Co., 7171 E. McNichols Rd., Detroit 12, Mich.

Designated Model 1129-SP, the gear speeder uses enclosed spindles and a special built-in listening horn for better definition of noise characteristics for this particular application. The machine can be provided with fittings for contact microphones and other acoustical equipment.

In operation, only one spindle is driven with brake loads applied to the opposite spindle. The driven spindle is reversible. Control of the gear speeder uses push buttons and manually operated handles. Four spindle speeds (580, 870, 1160 and 1740 rpm) are obtained from a four-speed constant-torque $^3/_4$-hp motor. The motor has a sealed sleeve bearing and dynamically balanced. The external contact friction brakes are manually operated and accommodate a variable load.

The speeder will accept gears up to a maximum diameter of 23 in. with a maximum face width of 10 in., the company reports. Center distance range is $2^1/_2$ to 12 in. Distance between centers on both front and rear spindles is 25 in. Floor space requirements are $46^1/_2 \times 99$ in.

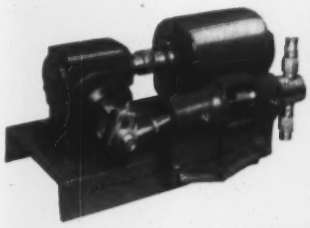


Scale deposits on steam turbine blading. Photo courtesy of Hartford Steam Boiler Inspection & Insurance Co.

No Build-Up! No Blow-Up!

. . . WHEN MODEL 1106 PROPORTIONEER FEEDS BOILER WATER CHEMICALS

Prevent scale build-up (caused by boiler carry-over) on turbine blades with proper raw water or internal steam boiler treatment. Model 1106 Proportioneer feeds all chemicals (alkaline, neutral, or acid) accurately (guaranteed within ±1%) over 15 to 1 range. Capacities range from 0.11 to 35.6 GPH . . . for discharge pressures up to 1100 psig.

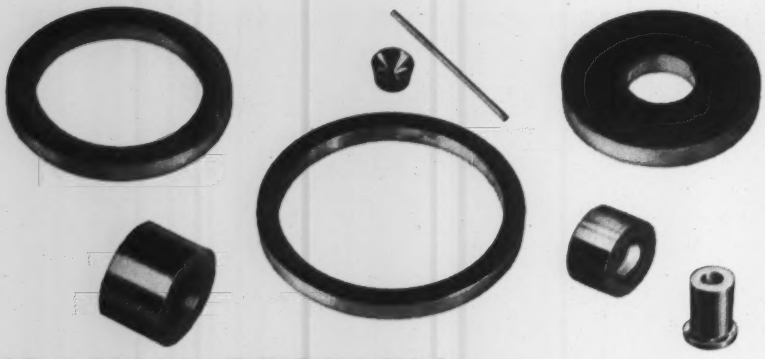


PAY LESS, GET MORE!

Design features of this proportioning pump include interchangeable measuring cylinders, super-accurate Vane-Guide check valves, and percentage calibrated stroke-length scale.

Request Bulletin 1106-2 for complete data. Write to PROPORTIONEERS, INC., 382 Harris Avenue, Providence 1, Rhode Island.

PROPORTIONEERS, INC.
DIVISION OF
B-I-F INDUSTRIES
PROVIDENCE, RHODE ISLAND
BIF METERS FEEDERS CONTROLS



IS YOUR PROBLEM:

WEAR plus severe CORROSION?

Then you'll be interested in investigating Kennametal* Grade K501

Kennametal Grade K501, a platinum bonded tungsten carbide, was developed especially to meet conditions where severe abrasive conditions as well as corrosive agents are encountered. While K501 equals the corrosive resistance of the noble metals, it is lower in cost, and has a much higher resistance to wear.

Here are results of laboratory corrosion tests, showing comparisons with other metals which were developed specially for corrosion resistance:

	STRENGTH % by WT.				TEMPERATURE				LOSS† mg/dm/d			
SOLUTION	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM	Kennametal K501	Monel Metal	Hastaloy B	Kennametal KM
Nitric Acid (HNO_3)	5	Above 1	—	5	Boiling	Above 80°F	—	Room	0	Not	—	587
Sulfuric Acid (H_2SO_4)	5	Above 20	10	5	Boiling	Boiling	Boiling	Room	0	Recom-	85	161
Hydrochloric Acid (HCl)	1.25	All	10	5	Boiling	Above 120°F	Boiling	Room	74	mended	77	245

†Tests of one week duration Note: The above tests are indicative of what may be expected in service, but it is recommended that specific tests under specific conditions be made.

In addition to its unusual abrasion and corrosion resistance properties, Kennametal K501 has a Hardness of 91.8 Rockwell A, Transverse Rupture Strength of 125,000 psi, and a Specific Gravity of 15.50. These unique properties suggest its use in valve parts, nozzles, seal rings, balls, non-lubricated guides and bushings, and other parts exposed to strong mineral acids, fuming nitric acid, and similar highly corrosive agents.

Made by Kennametal's exclusive methods of powder metallurgy, K501 can be produced in many complex shapes to close tolerances to meet the requirements for specific parts. It can be fastened by brazing.

Why not investigate Kennametal K501? It may be the answer to your problem. Write KENNAMETAL INC., Latrobe, Pennsylvania.

*Kennametal is the trademark of a series of tungsten and titanium carbides which have exceptionally high resistance to the destructive forces of abrasion, corrosion, erosion, deflection, deformation, high temperature oxidation and impact.

B-9903

INDUSTRY AND KENNAMETAL ...Partners in Progress

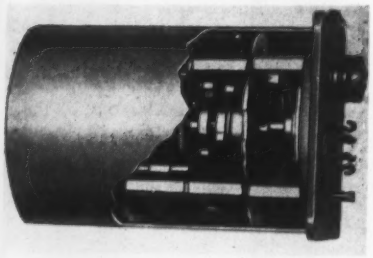
KEEP INFORMED — NEW EQUIPMENT, BUSINESS NOTES, LATEST CATALOGS

Steam Solenoid Valve

A new packless steam solenoid valve has been introduced by Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

The company says the two way Bulletin 8222A valve may be used in a variety of applications for the automatic control of the flow of steam, hot fluids or gases up to 400F. They are used in heat exchangers, industrial cleaning machines, commercial dish washers, sterilizing machines and systems, dry cleaning machines, the firm reports.

The internal pilot operated solenoid valve has a forged brass body and bonnet. Teflon disks are provided.



Lightweight Timer

A new hermetically sealed time delay relay measuring approximately $2^{3}/_{8} \times 2^{3}/_{8} \times 3^{5}/_{16}$ in. and weighing 30 ounces or less is available from Eagle Signal Corp., Industrial Div., Moline, Ill.

The Type 825 Timer meets all environmental requirements for aircraft and ground installations, the company reports. The unit is available with from one to six contacts; with time cycles from fractional seconds to multiple hours. Timer shown has provision for external timing adjustment.

A synchronous timing motor is used for 60 and 400 cycle applications. For d-c applications, either a permanent magnet type motor or a governor controlled motor may be used, depending on accuracy requirements.

Oil Tight Push Buttons

Furnas Electric Co., 1048 W. McKee St., Batavia, Ill., announces heavy duty oil tight push buttons, rated to 550 v a-c—d-c.

The new line includes push buttons, selector switches, selector push buttons, pilot lights and accessories such as mushroom head, lever and key lock. All units are built around one standard contact block, without rights or lefts. These contact blocks can be used singly or in tandem, mounted vertically or horizontally, the firm states.

The operator consists of a metal button or selector knob which is free to slide or rotate within a metal sleeve. A special oil seal prevents oil from entering the enclosure and the switching mechanism. All visible metal parts are chrome plated or anodized.

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Research Microscopes

A new series of research microscopes with push-button illumination has been announced by Bausch & Lomb Optical Co., 635 St. Paul St., Rochester, N. Y.

The microscopes, known as the "R" series, incorporate many of the firm's standard Dynoptic research design features, with several major new developments in substage equipment.

Most important of these developments, according to the company, is an achromatic variable focus condenser which for the first time provides "push-button" illumination. The new illumination system's operation uses unusually large lenses in the condenser, a graduated numerical aperture scale, and a knurled ring for setting the lens system, the firm states.

With the condenser in contact with a specimen slide, and with the correct illuminator, the field and numerical aperture of any objective from 30 mm to 1.8 mm can be filled. It also is said to eliminate the need for auxiliary condensers to fill the field when a 30 mm, 3.5X objective is used.

Conventional Abbe and Panfocal condensers are also available. For photomicrography, measuring, microprojection and other special applications, a monocular body with a graduated draw tube can be substituted for the standard binocular body.

Compacting Press

A compacting press, said to be advanced in rigid design and engineered for increased versatility through easy application of accessories, has been developed by the Hamilton Div., Baldwin-Lima-Hamilton Corp., Box 146, Hamilton, Ohio. The press is designed principally for powdered metals.

According to the company, the welded steel frame of the press, the 30-W, supports the die set on all sides, directly applying its own rigidity to the working parts. Pressure-rated at 30 tons, the unit can be equipped in the field with such accessories as an independent floating core rod support for the forming of blind or counter-board holes, the company claims.

Other accessories, all packaged and fitting into place without machining of any kind, include a cushion cylinder to operate a secondary top punch, pre-pressing die control, dual ejection mechanism and precision indicators for adjustments.

Drive is variable speed and the range of the machine is from 10 to 40 strokes a minute.

The core rod floats with the die as the floating die holder and the core rod support are an integral unit. The unit can float through an adjustable range up to $2^3/_4$ in., the firm states.

Head stroke is $6^3/_4$ in., the same as the opening between the bottom of the top punch and the top of the die (maximum daylight). Ejection capacity of the machine is 20 tons and the ejection stroke is adjustable up to $4^1/_2$ in.

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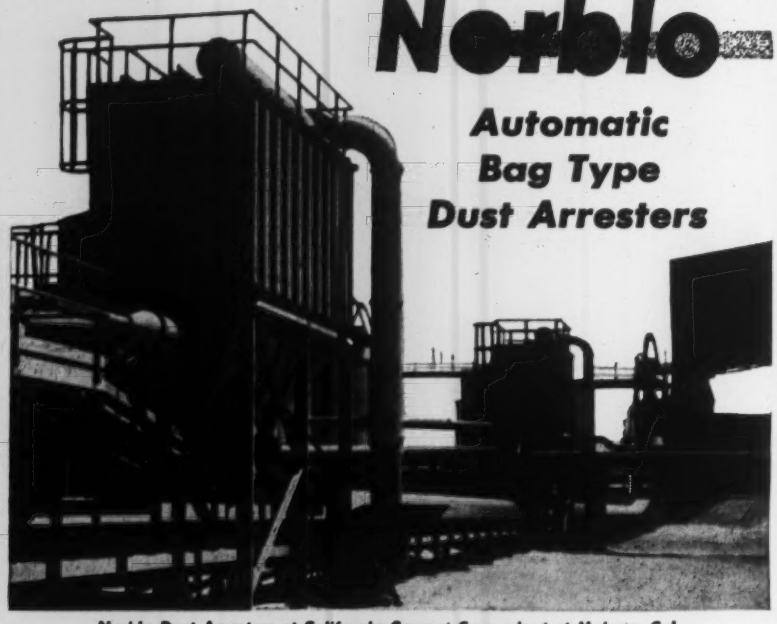
Automatic Bag Type Dust Arresters

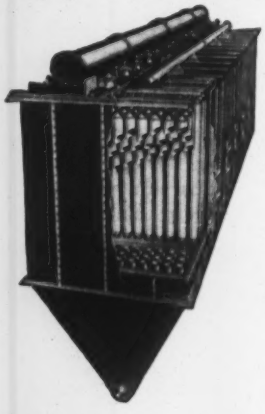


Norblo Dust Arresters at California Cement Corp. plant at Mojave, Cal.

Twenty-four hours a day is a gruelling grind, but Norblo equipment takes it. What's important to plant owners and operating staff is that full dust collecting efficiency holds level during the day and night punishment.

Norblo installations include a group of basic compartment units, each housing 78 cylindrical bags. Variable cyclic cleaning involves one compartment at a time, and that for only a few seconds. Engineered to the needs of each installation, there's ample capacity without waste, but without undue strain on the equipment. Easy maintenance is provided for.

Users of Norblo Equipment in cement plants, industrial plants of many types, and mining and smelting agree that complete satisfaction is assured when you install Norblo. Write for information—state your dust collection problem.



Norblo also builds centrifugal and hydraulic dust collectors, exhaust fans, cement air cooling systems, and portable type dust collectors.

The Northern Blower Company

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Norblo ENGINEERED DUST COLLECTION SYSTEMS FOR ALL INDUSTRIES

KEEP INFORMED — NEW EQUIPMENT, BUSINESS NOTES, LATEST CATALOGS

Press Bending Machine

A high speed process for producing bent ferrous or nonferrous tubular parts in which two or more bends of varying angles must be in accurate relationship is introduced in a new press-type bending machine announced by Walter P. Hill, Inc., 22183 Telegraph Rd., Detroit 19, Mich.

The press bender is described by the firm as a compact, horizontal-type, hydraulic-powered machine. Accuracy of bend relationships is assured by clamping one end of the tubular part and holding it stationary while a bend is produced on the other end by a hydraulic powered press ram and wiper die assembly.

The company says this arrangement provides maximum operator safety, and allows other bends in the part to be produced in sequence in accurate relationship; with the tubing held stationary for each bending position in fixtured radial location to the previously-produced bend.

The bending operation can be performed with or without a mandrel according to the particular tubing requirements. The wiper die and mandrel assembly move with the tubing as it is bent, thus avoiding die marks and wrinkles in the bent parts, the firm states. Travel of the press ram and wiper die assembly can be controlled in sequence to produce bends of different angles in a single part in an automatic bending cycle.

The press bender produces two bends with different bend angles in accurate relationship in 2-in. diam welded steel V-8 engine exhaust manifold crossovers at a net production rate of 650 pieces per hour. A 1000-psi hydraulic system powered by a 30-hp motor and a 40-gpm pump operates the ram, mandrel, and wiping die cylinders. The die clamping system is powered by a separate 2000-psi hydraulic system powered by a 5-hp motor and a 3-gpm pump. The machine occupies a floor space about 5 × 8 ft and is 45 in. high.

Differential Pressure Pickup

A new differential pickup in which a dry strain-gage element is isolated from the pressurized fluid has been developed by Dynamic Instrument Co., Inc., Cambridge, Mass.

According to the company, the units are suitable for applications in rocket engines, gas turbines, and chemical processing systems, where differential measuring or pressure control devices are used in conjunction with corrosive or conductive fluids.

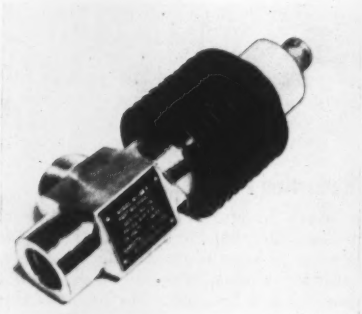
Pressure differences are transmitted from a single diaphragm through a mechanical linkage to an unbonded strain-gage element capable of high-frequency performance. Only Teflon and No. 18-18 stainless-steel parts come in contact with the pressurized fluid. Models are available for sensing pressure differentials from $\pm 1/2$ psi to ± 1000 psi at line pressures up to 2000 psi.

Isolation of the strain-gage element is accomplished by a double chamber arrangement, the company explains. The differential pressure chamber contains a single pres-

sure-sensitive diaphragm and provide fluid inputs on either side of the diaphragm. Diaphragm deflections are transmitted by a hinged linkage through a force-transmitting seal into a separate chamber containing the strain gage. This linkage-seal system has a high natural frequency and the full sensitivity of an unbonded strain gage can be utilized. Total linkage travel is about 0.00035 in.

The output signal resulting from a line pressure of 2000 psi is less than 1 per cent of full-scale output. Resolution is better than one part in 2500. Pressure inputs are made through $^1/_8$-in. pipe thread connections at either end of the pickup case. Also, $^7/_{16}$-in. No. 20 straight thread connections can be provided. Standard units operate with either a-c or d-c excitation at 6, 12 or 15 v, with bridge resistances at 350, 600 or 800 ohms and minimum full-scale outputs of 20, 40 or 50 mv, respectively.

Measurements are accurate to 0.5 per cent of full scale at 70 F. In many applications, output signals are large enough to be used directly without amplification, the company states. Insulation resistance from pickup case to ground is 100 megohms minimum, and hysteresis is less than 0.5 per cent of full scale. Temperature range is −65 to +350 F. The electrical connector is supplied.

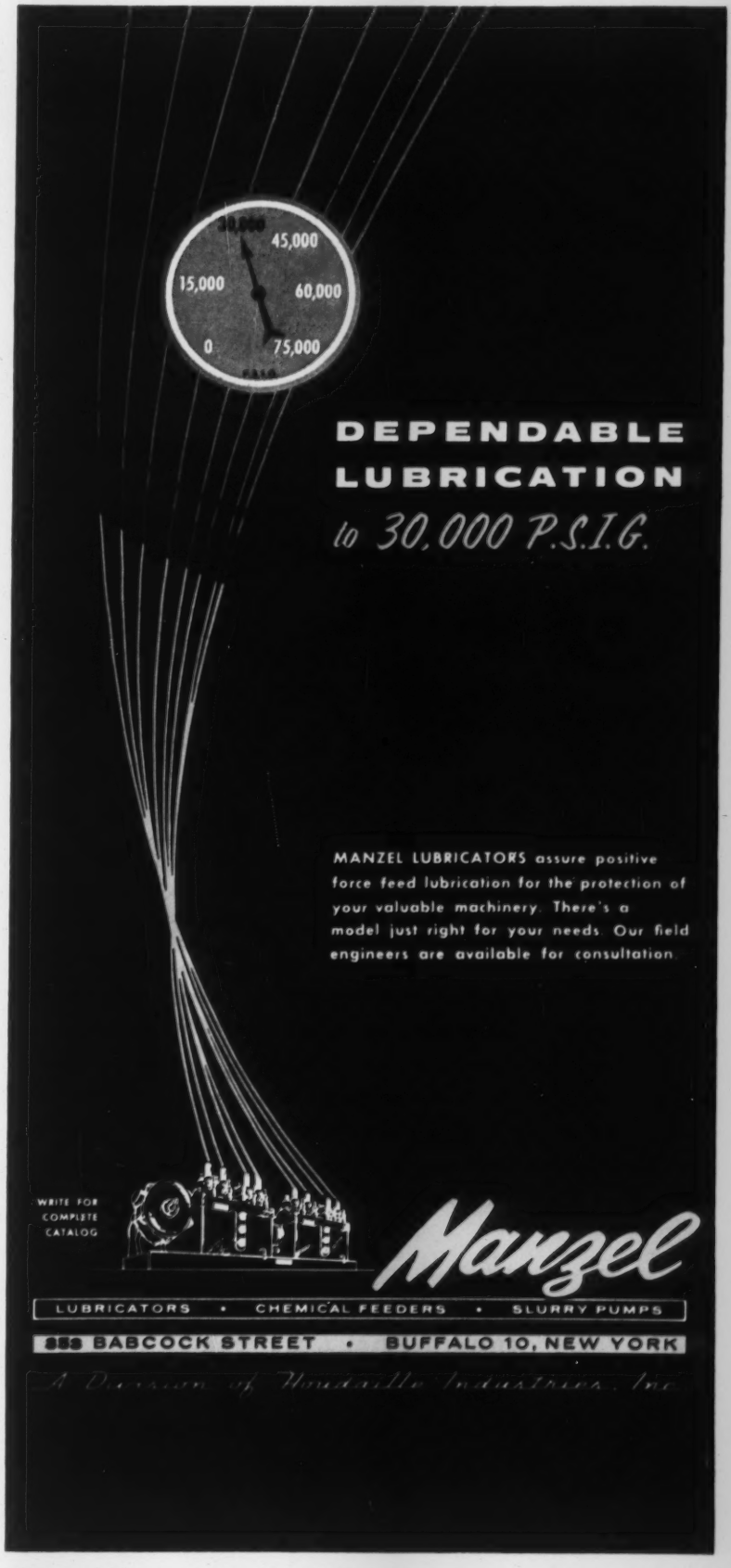


Solenoid Valve

Air temperatures to 1000 F and air pressures to 4000 psi are said to be controllable by a 24 volt d-c pneumatic solenoid valve designated Model MV36R, introduced by Marotta Valve Corp., Boonton, N.J.

Final temperature rating is not yet established, according to the firm, but over fifty tests have been accomplished with line fluid temperatures between 700 and 1000 F. The valve under test is normally closed and is the $^1/_2$ in. AND tube size. The manufacturer will supply the valve in a range of sizes from $^1/_4$ to 2 in.

Flow characteristics are similar to those of an elbow fitting of the same size, actuation time is less than .050 second, and internal leakage is negligible, the firm states. The valve can be made available also for liquid oxygen and high temperature hydraulic applications.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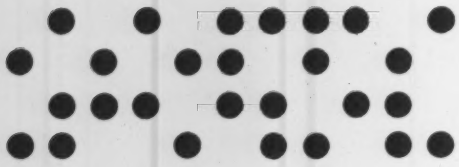


COMPUTERS

If you are an experienced computing analyst—or if computing and data reduction are new to you but you are a qualified engineer—there is interesting work as well as a bright future for you in Northrop Aircraft's growing Computer Center at Hawthorne, California.

Applied mathematicians and engineers are needed as computing analysts for assignment to Northrop's analogue computing facility, as well as the newly expanded digital electronic computer department which provides unparalleled service in the practical solution of complex engineering problems.

Northrop has many openings on its other projects having to do with jet aircraft and missile design. They include positions for electronics and electro-mechanical engineers and lab technicians. In addition to attractive compensation, Northrop offers benefits unexcelled in the airframe industry as well as helpful cooperation by forefront engineers for your professional advancement.

You'll like the comfortable working conditions, friendly people and modern equipment at Northrop. And you and your family will be living in Southern California where sea, mountains and desert offer year 'round recreation.

If you qualify for any phase of computer research, design or application, we invite you to contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-D, Hawthorne, California.

NORTHROP

NORTHROP AIRCRAFT, INC., HAWTHORNE, CALIFORNIA

Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

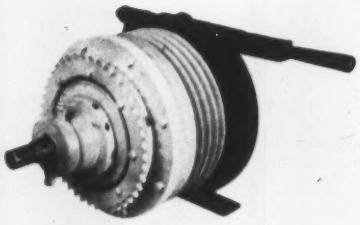
8-A-90

Electronic Air Cleaner

An electronic air cleaner which is claimed to be cheaper to own and operate than some mechanical filter systems and up to 20 times more efficient is announced by Sturtevant Div., of Westinghouse Electric Corp., Box 2278, Pittsburgh 30, Pa.

The new unit is said to be less than half the size of standard electronic air cleaners. Developed to fit the needs of commercial buildings, the new Precipitron cleaner model will bring savings of up to 35 per cent over previous costs for electronically cleaned air, the company states. Installation costs of the new model have been reduced through the elimination of conventional cell-to-cell high-voltage wiring and the need for specially constructed foundations.

The new cleaner was designed to allow an increase in air velocity from 330 fpm to 600 fpm. Where original cost on older models amounted to 20 cents per cfm of clean air, the new unit cost per cfm of clean air is 14 cents, the company reports.



Reduction Pulley

A new adaptation of the firm's reduction pulley, equipped with internal planetary gearing to provide speed reductions up to 8000:1, is now available for two speed operation and may be supplied for V-belt drive or adapted for chain or gear drive, it is announced by Hart Reduction Pulley Co., 426 W. Main St., Waukesha, Wis.

Two clutches are provided. According to the company, a standard disc clutch locks the housing direct to the shaft and gives normal V-belt reduction, while a drum type clutch, built into the pulley and operating through the internal gearing, permits much larger reductions. By the use of two built-in drum type clutches, two internally reduced speeds may be obtained. These two speeds may be in the same direction, or one forward and one reverse.

Instead of disc or drum type clutches as shown, the unit may be equipped with almost any type of electrical, mechanical or pneumatic clutch, the firm states. Clutches may be remotely controlled if desired.

The pulleys can operate either horizontally or vertically, are entirely sealed, equipped with hardened gears and running in oil. Overload release is available.

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Air Control Valves

Ross Operating Valve Co., 120 E. Golden Gate Ave., Detroit 3, Mich., announces a series of air control valves, called Starline, designed to provide modular construction for flexibilitiy in applications.

Five new pilot heads which are interchangeable on seven valve bodies, provide 35 major model combinations. Available pipe size increases the variety of combinations to 210 models the firm states.

The White Star valve is composed of a spool solenoid pilot head and any one of the seven valve bodies. The firm's engineers said that tests indicate a normal life of more than 20 million cycles.

The Gold Star valve consists of one of the seven valve bodies operated by a newly developed, large capacity, pilot section actuated by the new long life, oil immersed solenoid. Built to JIC standards, it has a tested life of more than 40 million cycles, the company states.

The Blue Star group includes all the remote piloted, pressure operated valves. The MV master valve gives immediate actuation and immediate reversal. The TD sequence valve is timed-in and the WV is timed-out. These heads are also interchangeable.

Indoor Power Centers

Kuhlman Electric Co., Bay City, Mich., introduces a line of indoor power center transformers for 300 kva and below. These completely self-contained, compact, attractive units are designed for lighting circuits, small industry and commereial buildings.

Bulletin CS-1010 gives engineering data, weight, dimensions and detailed schematic drawings of the new power centers.

Equipment Mount

Barry Controls, Inc., 920 Pleasant St., Watertown, Mass., announces a model B-64 All-Angl Barrymount with maximum load ratings up to 40 lb per mount to give heavy electronic equipment protection against the severe vibration environment in high performance jets and missiles.

The new unit is dimensionally interchangeable with standard MIL-size 2 mounts. Design of the mount is said to be a radical departure from standard MIL mounts in that isolation continues through all flight attitudes.

MIL-C-172B type isolators are designed to work in a horizontal position and may be required to operate at a maximum inclination of 10 deg. The B64 gives continuing isolation through all positions in jets and missiles, during steep climbs, dives, and maneuvers, the company says. For these applications the isolators are designed to mount equipment at a natural frequency of 15 to 30 cps or higher.

According to the company, the high degree of damping in this mount is effective in keeping transmissibility at resonance below 3. Since the damping is effective in all

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Here's the table that allows a draftsman to reach (and work on) any part of his board, easily, while sitting or standing! And here's how it's done. Two simple controls adjust board height and slope—move any area of the board instantly, effortlessly to the most convenient working position. Draftsman fatigue is sharply cut down, productivity dramatically steps up.

For your new drafting department, or present one, why not get the table that gets more work done? It will pay you to talk Auto-Shift with your Hamilton dealer.

Hamilton
drafting equipment

And Auto-Shift puts more draftsmen to work in available space. Designed for row installations, there's a reference desk behind each draftsman. Six men work where four do now!

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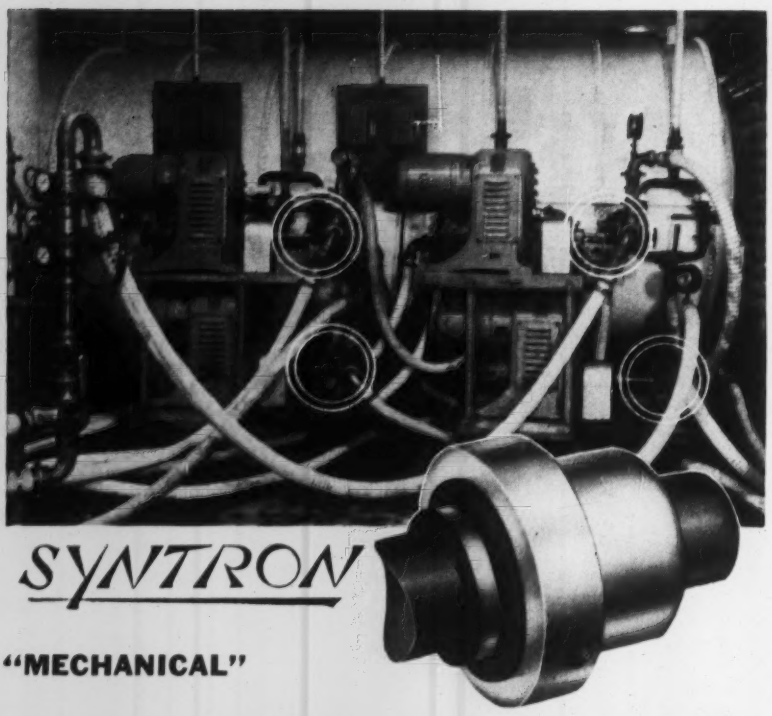

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SHAFT SEALS

Provide a positive trouble-free seal around rotating shafts

Syntron Shaft Seals are successfully handling difficult liquids and gases. Provide a positive-leak proof seal around rotating shafts for long periods without maintenance or adjustment.

Syntron Shaft Seals are built as a single, easy to install unit. Seal faces are lapped to precision flatness. Inner sealing parts rotate with shaft—will not score or damage shaft. Self-lubricating, automatic pressure balance eliminates periodic adjustment and maintenance.

Stop leak waste, lower maintenance costs. Meet your sealing problems with Syntron Mechanical Shaft Seals . . seals of proven dependability.

Write to our application engineers for recommendations.

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SYNTRON COMPANY

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directions, transmissibility at resonance remains at this desirable low level regardless of the direction in which the isolator is loaded, the firm states.

The mount has been tested at −65 to 120 C and shows negligible change in performance at these extremes of temperature. Performance is also unaffected by the salt spray, humidity, and sand and dust environments of MIL-E-5272A.

A new wide-flange countersunk core is available with the mount to permit seating of the attachment screw in a dimpled base and improve structural integrity and stability of the mounted system under shock.

Vibration Testing Machine

Ahrendt Instrument Co., 4910 Calvert Rd., College Park, Md., announces a machine for economical vibration testing of small items up to 5 lb max. The Model 14-28 vibration testing machine meets frequency and amplitude specifications of MIL-STD-202.

The machine weighs 30 lb and is portable for interim testing during development as well as for final test or production line quality testing, the company states.

Variable speed drive mechanism and $^1/_{18}$ hp split phase induction motor are housed in a cast aluminum base. Linear sinusoidal motion is imparted to the spring flexure mounted table by means of a connecting rod driven by a ball bearing mounted eccentric cam.

Frequency adjustment is provided from the front of the machine and is infinitely variable while the machine is running from 10 to 55 cps. Frequency of from 2 to 55 cps also available at additional cost.

Amplitude setting from 0 to 0.040 in. (double amplitude max 0.080) is provided at the top right side of the table by means of the eccentric adjustment.

Hydraulic Flow Divider

A flow divider, designed for use in the dividing of hydraulic force for two or more operations on equipment has been developed by the New Products Corp., 3636 Oakton St., Skokie, Ill.

The divider can be adjusted with an ordinary screw driver to control the flow over a range from 10 to 95 per cent as the circuit may require. The firm states the unit has a built-in relief valve that will pass the oil back to the sump when the peak pressure setting of the secondary flow is reached.

The divider is so designed that when the pressure of the primary operation begins to build up, the flow to the secondary operation begins to decrease. This means, the company says, that on a fork truck for instance, no power in lifting will be sacrificed to power steering.

The divider permits two simultaneous operations from one pump. It operates on low circulation pressure from the pump and divides the flow in any desired proportion. It is reported to be unaffected by temperature.

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Plastic Panels

A new line of glass fiber-reinforced plastic panels featuring embedded aluminum or steel diamond mesh has been announced by the Resolite Corp., Zelienople, Pa.

Called "Security Junior," the new panels have high impact resistance. In aluminum, they consist of .081 gage expanded aluminum embedded in flat sheets using $1^1/_2$ oz Fiberglas mat. In steel, the panels consist of 16–18 gage expanded steel embedded in similar sheets of flat Rasolite.

The plastic sheets are available in both standard Resolite and in a special, highly fire-retardant type, in clear and in five colors—ice blue, pale green, yellow, sky blue, and coral. They have light transmission values ranging from 71 per cent (clear) to 15 per cent (coral). The average light transmission value is 50 per cent.

Valve Stem Packing

Garlock Packing Co., 403 Main St., Palmyra, N. Y., has announced two new styles of asbestos braid jacketed plastic core valve stem packings for high pressure and/or high temperature service. Designated Styles 5855 and 127, the new packings both utilize inconel wire in the packing jacket.

Style 5855 is for general service stem valve packing where conditions are not extreme, including top stuffing box temperature range of 500 to 600 F, and pressures of several thousand psi. Style 5855 has a jacket composed of commercial asbestos yarn reinforced with inconel wire and with a corrosion inhibitor.

Style 127 is for use in packing any fluid which will not affect the asbestos. It is suited to extreme heat conditions, such as box temperatures of 750 F and pressures to several thousand psi, the company says. It will withstand considerable super heat, and is an excellent high temperature oil refinery packing. Style 127 has a jacket composed of 90 per cent asbestos yarn reinforced with inconel wire and with a corrosion inhibitor.

Metal End Mills

A self-gaging design said to minimize grinding time plus quick-change diameter adjustments are features of a new series of inserted carbide tipped blade straight shank end mills available from Goddard & Goddard Co., 12280 Burt Rd., Detroit 23, Mich.

Diameters range from 1 to $2^1/_2$ in.; length of cut is $1^1/_2$ or 2 in.; shank lengths from $2^1/_4$ to $3^1/_4$ in.; and shank diameters from 1 to 2 in. that fit standard end mill holders. Right-hand cut is standard.

Blades are held securely in the cutter bodies by replaceable serrated wedges that combine to produce firm's crosslock construction. For quick adjustment, cutter diameters can be increased in $^1/_{32}$-in. increments by setting our blades one serration. The company says gages are not required to check uniformity of blade projection.

Using vertical polarized light on a cross-section of pipe, photographer Bernard Hoffman clearly shows the ravages of corrosive action.

Controlling Corrosion in Fluid Engineering

Corrosion seldom works alone. Together with heat, pressure and abrasion factors, it compounds the problems of fluid engineering. But when you have valve design problems involving corrosion, you can look to the engineering leadership available at S. Morgan Smith for assistance.

You can use R-S Rubber-lined Butterfly Valves, for instance, to handle many special applications. The rubber lining protects the entire valve body, gives you corrosion resistance with maximum economy. Where your processing problem demands additional engineering, you can draw on the broad SMS background of experience in specialized valve applications.

There is a complete SMS line – Rotovalves, R-S Butterfly Valves and Ball Valves – to meet your fluid control problems. To obtain full information, contact our nearest representative, or write S. Morgan Smith Company, York, Penna.

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Ferromagnetic Plastic

A new flexible ferromagnetic plastic, trademarked Ferrotron, is now available in sample kits from Polymer Corp. of Pennsylvania, Reading, Pa.

The flexible iron powder product is in rod and tape form. Rod diameter sizes are $^1/_8$, $^3/_{32}$ and $^1/_4$ in. The tape is $^1/_2$ in. wide and stocked in thicknesses of 4, 8, 16 and 32 thousandths of an inch. These and other sizes are available in production quantities.

Not a magnetic recording tape, this iron powder product is unique in that it is as flexible as paper and yet possesses such unusual properties as good dielectric strength, constant magnetic permeability over a wide range of frequencies and excellent moisture and temperature resistance, the company states.

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All-Purpose Lift Truck

A pneumatic tire lift truck said to have the compactness to work inside a single-door boxcar, yet have the traction and capacity to handle 7000 lb loads over rough yard terrain has been developed by Hyster Co., 2902 NE Clackamas St., Portland 8, Ore.

The unit has been designed to meet the needs of lumber and building supply dealers, concrete products manufacturers, stevedoring concerns, and other businesses requiring a heavy-duty maneuverable truck which can handle large unit loads within confined yard and storage areas, the firm states. The truck has a turning radius of 100 in. and a length of 106 $^3/_8$ in.

The truck is equipped with pneumatic tires, and a heavy-duty Hercules gasoline engine. The company says large bore and stroke enables this 70 hp engine to develop a rated torque of 182 lb-ft at 1200 rpm.

Hydraulic booster-type power steering is standard equipment. The unit also features center point steering with rugged steering axle which pivots about the longitudinal axis of the truck to maintain tire contact over rough ground conditions, self energizing aircraft type brakes that have 166.4 sq in. of braking surface.

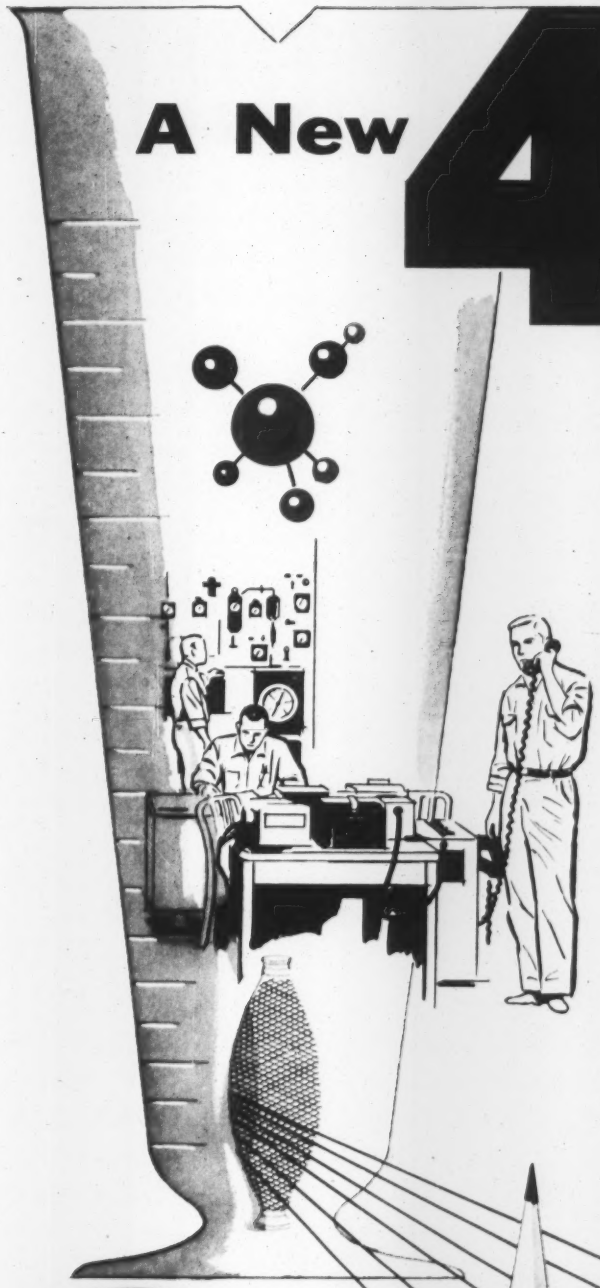
Continued on Page 56

DESIGNERS

WHAT major organization offers continual original work assignments?

For the answer turn to page 163

A New 4th Dimension in Engineering Careers



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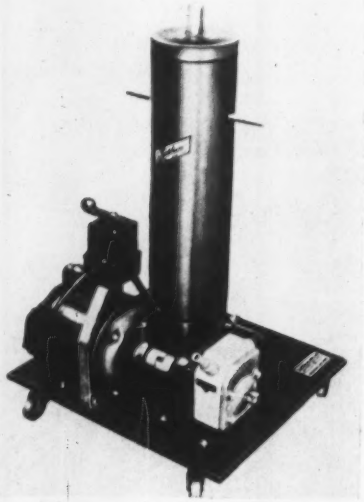
Miniature Gear Boxes

A series of precision, miniaturized gear boxes for electronic and instrument applications, servo-mechanisms, computers, small actuators and electronic components are available from Southwestern Industries Inc., 5880 Centinela Ave., Los Angeles, Calif.

Available in three series, Sizes 11, 15 and 18, the small, compact gear boxes have a range of gear ratios from 4:1 to 12,000:1. The Size 11 gear box provides torque up to 45 oz -in. Sizes 15 and 18 provide torque up to 65 and 100 oz -in., respectively.

Precision ball bearings are used throughout with sealed, permanently lubricated bearings used on the output stage. The gear boxes are designed so they can be mounted directly to small electric motors.

Sixe 11 is 1.062-in. in diam, 1.55 in. long, and weighs 2 to 4.5 oz. Size 15 is 1.437 in. in diam, 1.82 in. long, and weighs $2^1/_2$ to 5 oz. Size 18 is 1.750 in., in diam., 1.90 in. long, and weighs $2^1/_2$ to 5 oz.



Self-Priming Pump

A new all plastic, self-priming filter pump with a special Dynel filter medium to remove particles down to one micron in size from acid or alkaline electroplating and industrial solutions, has been developed by Sethco Mfg. Co., 70-78 Willoughby St., Brooklyn 1, N.Y.

The new pump is designed specifically for handling electroplating and industrial oxidizing agents such as chromic, fluboric and nitric acids that are to be circulated and continuously filtered. According to the company, the unit is also useful wherever all metal contact must be avoided, for its all-plastic construction is completely corrosion resistant and has no metal parts that are wetted.

The pump is designated VPHI-20. The pump has a polyethylene body and a Hypalon

impeller. It is self-priming, self-lubricating and will not leak, the firm states. It is coupled by a flexible coupling to a 1/4 hp totally-enclosed, ball-bearing motor, and can handle a filtering capacity of 50 to 300 gph, according to the manufacturer.

The filter chamber is fabricated of rigid polyvinyl chloride containing two Dynel filter tubes. The yarn is wound around cores of phenolic plastic to give fine filtration action.

According to the company, the acid-resistant acrylic fiber successfully filters solutions of chromic acid, iron and lead fluoborate, ferric chloride, silver nitrate, sodium hypoclorite and many other industrial and electroplating solutions. As a filter medium, the Dynel removes from solution particles down to one micron in size and has applications where other natural or synthetic fibers will deteriorate, the firm reports.

A unique feature of the filter pump is its reversing operation controlled by a switch to enable an operator to clean out the filter chamber almost instantly without dismantling. This back washing action is said to provide long cartridge life for improved economy.

Other features include a phenolic linen-surfaced base panel equipped with ball bearing rubber tire casters, and 20 feet of vinyl hose with a strainer for the inlet hose.

Digital Servo Indicator

A new, direct reading digital servo indicator, Model 143, said to supply a highly readable digital counter type indication has been announced by Gilmore Industries, 5713 Euclid Ave., Cleveland 3, Ohio.

According to the manufacturer, millivoltage or resistance changes developed by force, flow, weight, and temperature transducers are indicated swiftly, precisely and directly. The manufacturer further states that the direct reading digital counter eliminates the normal human errors, from parallax and interpolation of reading, that occur with dial and pointer scales. Accuracy is ±.1 per cent of span.

The indicator is said to be excellent for measuring any linear variable where values change throughout a wide range, and where precise, fast evaluation and high resolution are absolutely necessary. It is particularly applicable to the measurement of forces in conjunction with resistance bridge transducers and the measurement of flows with an impeller type pick-up, the company states.

The unit uses a continuous null balance servo system of operation in a two case, cable connected arrangement. The remote case is 18 in. wide, 12 in. high, 4 in. deep and incorporates a measuring circuit, a damping network, an amplifier, a converter and a power supply when necessary. The panel mounted indicator case measures 6 in. wide, 5 3/8 in. high and 14 5/8 in. deep. It contains a balancing motor, a slidewire and a digital counter.

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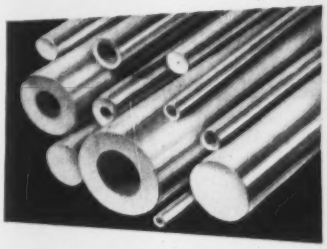

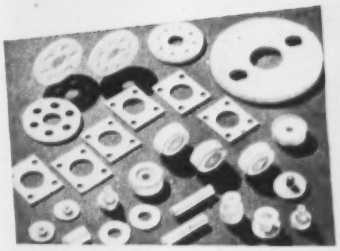

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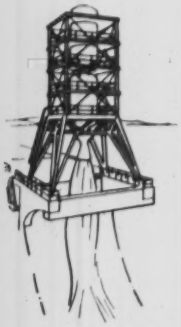

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Miniaturized Sphere Resolver

Vectron, Inc., 1564 Trapelo Rd., Waltham, Mass. announces a new miniaturized precision mechanical ball resolver for analog computation applications.

The 0.1248-in. diameter input shaft may be driven up to 100 rpm, and requires less than 5 inch-ounces at 25 C for an output of 1 to 2 inch-ounces at the 0.187-inch diameter sine and cosine output shafts, the firm states.

The 0.500-in. orientation shaft is concentric with the input and establishes the output relation with an accuracy of ±0.5 per cent over a 360-deg range.

This component is in the form of a block $1^1/_2$ in. square and $2^1/_8$ in. long, weighing less than $^3/_4$ lb. Output shafts on the standard unit extend $^1/_2$ in. from adjacent faces, each of which has precision mounting provisions.

The orientation input protrudes $^5/_{16}$ in. beyond the end mounting surface, while the rotational input shaft extends another $^5/_{16}$ of an in. Full material certification is available for military applications, the company reports.

Variable Speed Drive

Graham Transmissions, Inc., Menomonee Falls, Wis., announces a new high accuracy, infinitely variable speed drive for lightweight 400 cycle air force ground checkout and test equipment.

According to the firm, the new drive delivers speeds from any desired maximum to zero and into full reverse, if desired, without change of motor rotation, thus providing smooth and shockless reversal, It is said to be particularly suited for use on tachometer, gyro and accelerometer testers as well as integrating devices and other similar apparatus. Sizes from $^1/_{15}$ to $^1/_2$ hp with torques up to 750 in-lb are offered.

The drive is equipped with micrometer control providing hairline accuracy of speed holding and speed reset. The transmission is available with or without built-in reduction of either spur and worm types, the latter available with output shaft extending to either side or up or down Motor, transmission and reducer are designed to meet military specifications covering both high and low temperature operation.

The transmission is equipped with a newly designed 12 pole, light-weight, fungus treated motor. Speeds from as high as 10,000 rpm to zero or as low as 11 rpm to zero are available depending on the type of built-in gear step-up or reduction. Transmission and reducer are furnished with aluminum housings, or if required, with magnesium housings.

The entire package of transmission, motor and reducer is mounted with only four bolts and occupies less space than other drives of comparable power rating, the company says. The drive can be furnished with a variety of remote controls, including remote mechanical and remote electrical control designed for 400 cycle operation. Follow-up accuracies equal to plus or minus $^1/_{25}$ of 1 per cent of full scale can be had from electrical controls used to provide remote or automatic operation, the firm states.

Improved Ball Joint

J. J. Tourek Mfg. Co., 1901 S. Kilbourn Ave., Chicago 23, Ill., announces its Type "EC" ball joint, an improved design which features the location of the ball socket in the same unit as the cross drilled hole.

According to the company, considerable added wall thickness is provided by this method. A specially designed ball stud with a short neck enables more than 250 lb force to be applied on this unit, the firm states.

Swivel construction is assembled with a grease resistant neoprene washer to cushion movement and maintain proper tension. A spring clip is designed to allow rapid adjustment over great length, eliminating threaded rods and conventional set screws. Nut, lockwasher and spring clip are permanently assembled on the unit. Present usage for this ball joint includes automatic transmission, heating, ventilating and air control applications, the company reports.

Continued on Page 60

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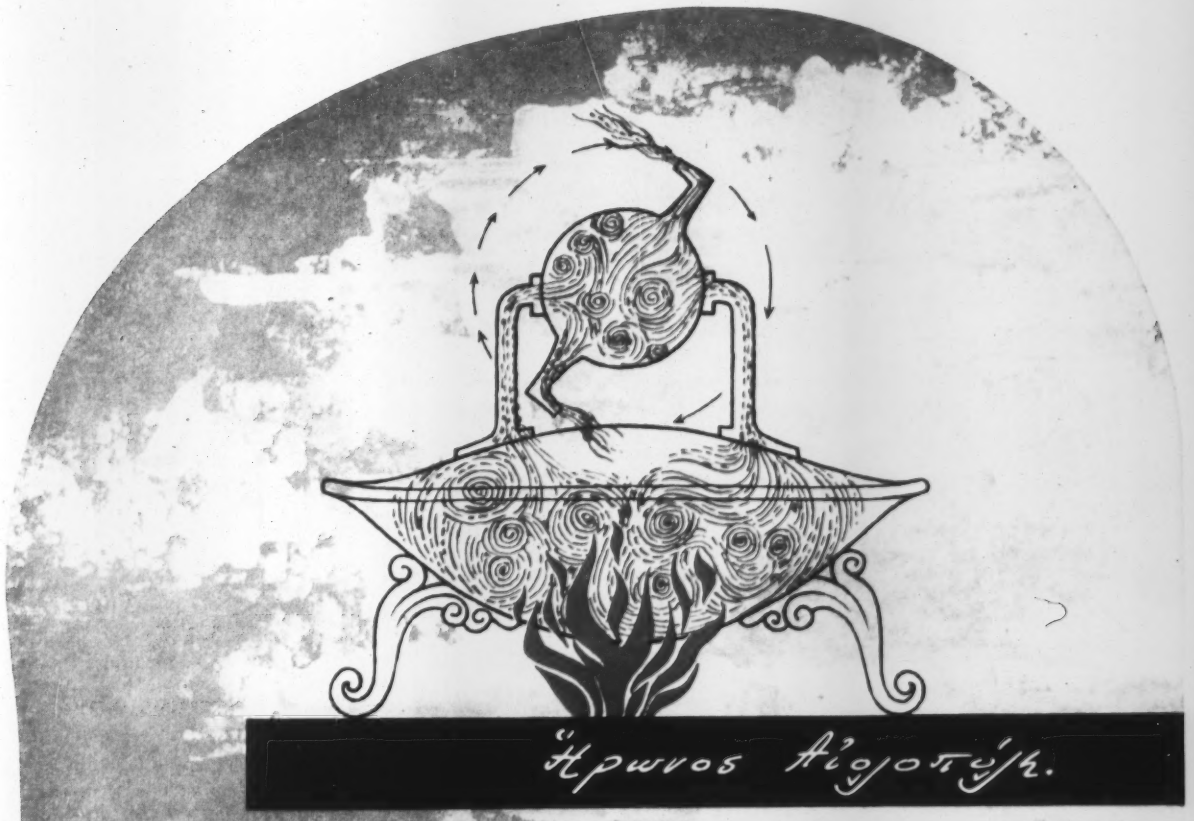

Heron's Aeolipile

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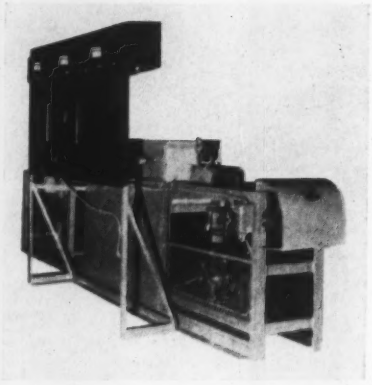

Transistor Furnace

A new electric furnace specifically designed for alloying, brazing and soldering of transistors and other semi-conductor products has been announced by BTU Engineering Co., 440 Somerville Ave., Somerville 43, Mass.

Designated as the "Transheat" furnace, it is custom designed, engineered and built to yield the time-temperature curve that is best suited for any given application, the firm states.

The furnaces incorporate a unique muffle design for controlled temperature profile and long life heaters, the company says. They also have controlled atmosphere and curtains and variable speed drives. The furnaces have non-comtaminable stainless steel belts and a temperature control system incorporating strategically located thermocouples for quick response, multiple temperature controlled zones for heating and cooling rates, and self-balancing input controls that maintain temperatures to within ± 0.25 per cent of the full scale range, the company says.

Teflon Tubing

Teflon tubing is now available in AWG wire sizes of 0, 1, 2, 3, 4, 5, 6, 7, and 28 and 30 from Polymer Corp. of Pennsylvania, Reading, Pa. Designated Polypenco Teflon spaghetti tubing, it has been currently available in AWG sizes 8 through 26.

The high temperature spaghetti tubing is used as a low and high frequency insulation sleeving for electronic component development, the company reports. The thin wall tubing has a minimum dielectric strength of 750 volts/mil, a low dielectric constant of 2.0 and a high surface resistivity above 10^{12} ohms per cm^2.

According to the company, the material permits assembly miniaturization because it combines outstanding electrical properties with a wide temperature service range of −320 to +555 F., zero water absorption, and resistance to flex and vibration. It completely resists soldering heats and is unaffected by bending and flexing during assembly, the firm states.

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NEW EQUIPMENT
BUSINESS NOTES
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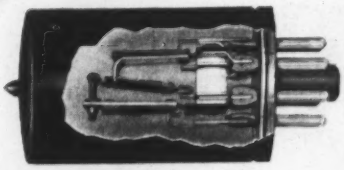
Centrifugal Pumps

Dean Brothers Pumps Inc., Indianapolis, Ind., offers a new line of standard, close coupled, centrifugal pumps designed to handle a wide range of general applications where conditions do not necessarily require a more costly engineered pump.

Identified as Type GSC, the line comprises seven pumps with capacity up to 600 gpm and total dynamic head up to 275 ft. Temperature range of liquids that can be pumped is from −40 to +250 F.

The line is available from stock in materials of three standard classifications: bronze fitted, all iron, and all bronze. Standard construction includes a removable back head to permit removal of the impeller without disturbing the piping; a large cradle opening for free access to the stuffing box; and a stuffing box adaptable, interchangeably, to packing and mechanical seal.



Time Delay Relay

Curtiss-Wright Corp., Electronics Div., Carlstadt, N.J. announces its "thermal memory relay," a bistable time delay relay with single pole, double throw snap action contacts.

The relay is thermally operated, having two separate heater circuits. Each heater serves to transfer a movable arm from one contact to the other. The relay being bistable remains in either of the two contact positions until operated by means of the appropriate heater circuit. Because of the thermal actuating characteristics, a time delay is associated with each operation, the company explains.

The bimetal strips are perfectly matched, thereby canceling the effect of ambient temperature upon relative deflection, the firm states. This compensation is said to insure consistent operation throughout the ambient range.

The operating time of the unit is factory preset for either 20 or 30 seconds on both transfers. The relays are temperature compensated from −55 to +100 C and have standard voltage rating of 6.3, 26.5, or 117 volts. Other voltages are available. Heater power is 2.7 watts for each heater. The relay has a life of at least 500,000 operations under average operating conditions, the company says.

For further information, please contact Thermal Devices Sales Department.

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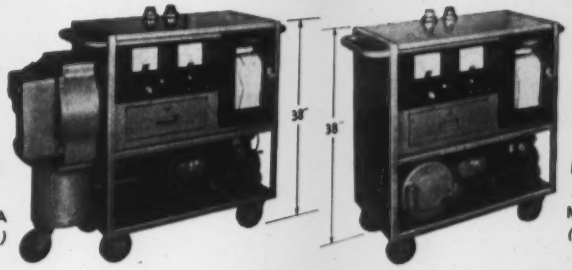

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(moving filter)

β, γ
AIR MONITOR
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AC provides financial assistance toward your Master's Degree. Graduate program also available evenings at Univ. Wisconsin, Milwaukee. GM's aggressive position in the field of manufacture and GM's policy of decentralization creates individual opportunity and recognition for each Engineer hired.

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CONVAIR MISSILES MAN?

Get the facts on **CONVAIR POMONA** in sunny California—*first* fully-integrated missile plant in the U.S.A.—designer and builder of the Navy's TERRIER supersonic, surface-to-air missile.

Naturally, you'll work with the most modern electronic equipment known. Better yet, you'll work with the kind of engineering talent that *creates* such equipment... that is pacing the advance of science into outer space.

You'll have the scope and help to show what you can do ...and top pay at every step you progress. You and your family will live (California-style) in the lush Pomona Valley at the foot of the snow-capped Sierra Madre. No commuting problems. Ample housing. True country living just 30 minutes from downtown Los Angeles.

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CONVAIR IS A DIVISION OF GENERAL DYNAMICS CORPORATION

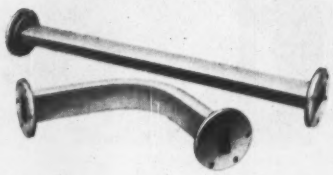
KEEP INFORMED — NEW EQUIPMENT · BUSINESS NOTES · LATEST CATALOGS

Heavy Duty Pump

A new constant displacement pump, designed for heavy duty, continuous 3000 to 5000 psi operations requiring 3 to 10 hp has been announced by Oilgear Co., 1560 W. Pierce St., Milwaukee 4, Wis.

Capacities at 3000 psi range from 233 to 1090 cipm (1 to 5 gpm) depending on the size and rpm of the driving motor. Said to be suited for use on die casting machines, large unjection molding presses, double acting or four-way differential presses, calender holddowns, or similar equipment involving high static loads over long periods under adverse conditions, the new pump is equipped with a purolator-type micronic filter under type designation "HG."

According to the manufacturer, this design provides 100 per cent filtration and cleaning of the hydraulic fluid before entrance to the high pressure axial piston end, and continues on to the operating cylinder or accumulator.



Microwave Components

Airtron, Inc., Dept. B, 1103 W. Elizabeth Ave., Linden, N. J., has recently expanded its product line to include component parts made from oxygen-free high conductivity copper.

Components such as straight sections, circular bends and adapters are at present available from the firm in the new material in the WR-137 waveguide size. Used in combination with standard flexible waveguide components and windows, they lend themselves to installation for microwave relay systems operating in the 6000 Mc region, the company says.

Because of this material's higher conductivity, oxygen-free copper waveguide components have, according to the firm, general application in indoor and outdoor cabinet arrangements of the various microwave relay systems, since the high conductivity property results in a much lower insertion loss for the extended waveguide runs encountered in these installations.

Oxygen-free high conductivity copper has an attenuation between 2.0 and 2.4 db/100 feet, whereas standard brass WR-137 has a waveguide attenuation of between 2.80 and 3.38 db/100 ft, and its aluminum equivalent waveguide has an attenuation of between 2.44 and 2.95 db/100 ft. In addition, the high conductivity copper waveguide was found by the company to be better than silver

plated brass because the attenuation of the plated material depends on plating thickness and polishing, and is thus unpredictable especially in producing components which have lengths of 5-6 ft or more.

These figures (based on the theoretical computed attenuation, adding a factor of 0.5 db/100 ft to allow for the actual attenuation obtained in production quantities) establish the superiority of oxygen-free high conductivity copper components for long transmission line applications, the company explains.

Besides a standard line of straight sections, circular bends and pressure adapters made of this material in the WR-137 waveguide size, the company has available standard pressure windows and flexible waveguide components, all with appropriate hardware for use in different types of microwave relay system installations.

Front End Loaders

A new line of tractor-mounted front end loaders is announced by Superior Equipment Div., Superior Pipe Specialties Co., Box 341, Wheeling, Ill.

The loaders feature a new extra-strong tubular frame, part of which acts as an hydraulic oil reservoir. Bucket rams are mounted so that they cannot "spring" and hydraulic piping is inclosed in loader arms for protection, the company says.

According to the firm, the loaders have an expecially strong "pry-out" action for heavy or frozen loads. They can be mounted on most models of low silhouette four-wheel industrial tractors.

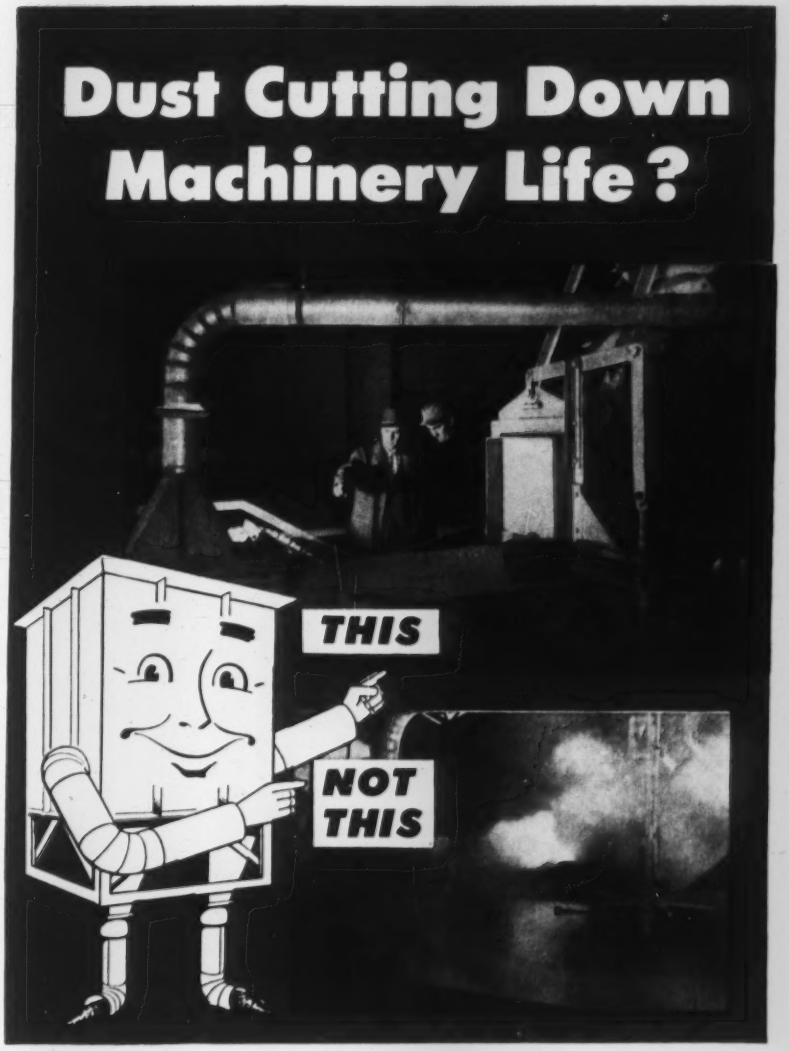
Hydraulic Press

A 1000-ton hydraulic press has been designed and built by Hydraulic Press Mfg. Co., Div., of Koehring Co., Mount Gilead, Ohio, for hot piercing high explosive 8-in. shells, said to be the first operation in the hot forging-cold extrusion process used in shell manufacture.

The press has a bed area of 66 × 60 in.; 98 in. daylight; 60-in. stroke; and is equipped with an 150 ton hydraulic ejector with a 24-in. stroke. The main ram has a closing and return speed of 1000 in. per min. and a pressing speed of 600 in. per min. The press is equipped with a pressure vessel of sufficient capacity to perform a high speed pressure stroke of 19 in., the company reports. The power system requires 530 hp for operation.

In using the hot forging-cold extrusion process in the manufacture of shells, hot piercing eliminates a very heavy tonnage press that would be necessary for the initial operation in the normal cold extrusion process, the firm states. Following the hot pierce, the same methods are used as in the cold extrusion process.

The press is one of five different type and tonnage presses required for producing shells by the hot forging-cold extrusion process.



You need Pangborn DUST Control in your plant!

Uncontrolled dust in your plant is a costly, needless expense. Dust wears away delicate machinery and clogs working parts, increases down-time and repair costs.

Pangborn Dust Control stops that. Pangborn Collectors trap dust at the source, clean so thoroughly that in the winter many firms cut heating costs by recirculating the already-heated, cleaned air.

In addition, Pangborn gives you the bonus benefits of lower housekeeping costs, more efficient employees, better employee and community relations and extra profits from any salvage value. Complete line of collectors for all jobs.

Discover how *you* can profit from Pangborn Dust Control—write for Bulletin 922, PANGBORN CORP., 2200 Pangborn Blvd., Hagerstown, Md.

Pangborn CONTROLS DUST

THOMAS
FLEXIBLE COUPLINGS
Give You Freedom From Coupling Maintenance

NO LUBRICATION

NO MAINTENANCE

NO WEARING PARTS

Future maintenance costs and shutdowns are eliminated when you install Thomas Flexible Couplings. These all-metal couplings are open for inspection while running.

They will protect your equipment and extend the life of your machines.

Properly installed and operated within rated conditions, Thomas Flexible Couplings should last a lifetime.

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES.

1 Freedom from Backlash Torsional Rigidity
2 Free End Float
3 Smooth Continuous Drive with Constant Rotational Velocity
4 Visual Inspection While in Operation
5 Original Balance for Life
6 No Lubrication
7 No Wearing Parts
8 No Maintenance

Write for Engineering Catalog 51A

THOMAS FLEXIBLE COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

KEEP INFORMED — NEW EQUIPMENT, BUSINESS NOTES, LATEST CATALOGS

Sub-Fractional Motor

A sub-fractional horsepower electric motor with special helical gearing for extremely quiet operation, has been designed by the Gleason-Avery Co., Auburn, N. Y.

The motor has been built to specifications for use in the operation of Swan humidifiers. As an integral part of the humidifying apparatus, the motor turns an evaporating drum at a speed of three revolutions per minute.

The drum is 5 in. wide and 13 in. in diam. It consists of two sheets of vinyl plastic, rolled from the center outward. It revolves in $4^1/_2$ in. of water, completely coating both sides of the plastic sheets, and giving a total evaporating surface of 70 sq ft with each revolution of the motor. A circulating fan, located behind the motor-drum assembly, blows air across the drum, evaporating the water, and dispenses the humidity into the atmosphere of the room.

Ratchet Pipe Threaders

Two new drophead ratchet pipe threaders with segmental dies are announced by Erie Tool Wks., Erie, Pa.

The threaders are offered in two size ranges: No. 1PR in all sizes from $^1/_8$ through $1^1/_4$ in. and No. 2PR in all sizes from $^1/_8$ through 2 in. The die heads on the Pipemaster drophead threaders change instantaneously, yet cannot fall out, the company claims. Two-way ratchet is provided.

Air Conditioners

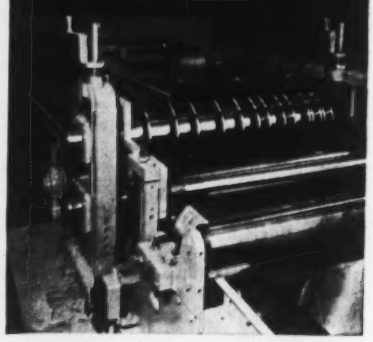
A new line of commercial packaged air conditioners said to feature advanced styling and numerous safety devices is now available from American Blower Div., American-Standard, Detroit 32, Mich.

Available in 3, 5, $7^1/_2$, 10, 15 and 20 ton ratings, the new models are recommended by the company for installation in restaurants, banks, schools, churches, hotels, small theatres, hospitals, offices, retail stores, public buildings, markets, small factories, shops and institutions.

Among the features of the new units is a new cabinet design. Heavy gage furniture steel is used for cabinet construction. It is coated with a rust-resistant primer and finished with grey metallescent enamel.

The company says that inside the unit is a new, efficient sloped cooling coil (evaporator) design which permits greater cooling area for a given coil size as compared with flat designs. Performance characteristics of the new sloped coil design are augmented by use of spiral aluminum and staggered copper tubes. According to the company, the greater air-coil contact achieved results in better heat and moisture transfer. The firm says the new conditioners also feature a more efficient draw-through air flow design. With air drawn through the coil, rather than blown through, cooling capacity is increased because air passes equally over every square foot of coil area, the company states.

YODER SLITTING LINES



PAY BIG DIVIDENDS WORKING ONLY ONE DAY PER WEEK!

In one plant, two Yoder tube mills and about 50 punch presses are being supplied with slit strands by one Yoder Slitting Line operated an average of only *seven hours per week*.

In another plant, a Yoder slitting line, *operated from six to eight hours per week*, is supplying two intermittently operated roll forming machines with total requirements averaging 100,000 feet per week.

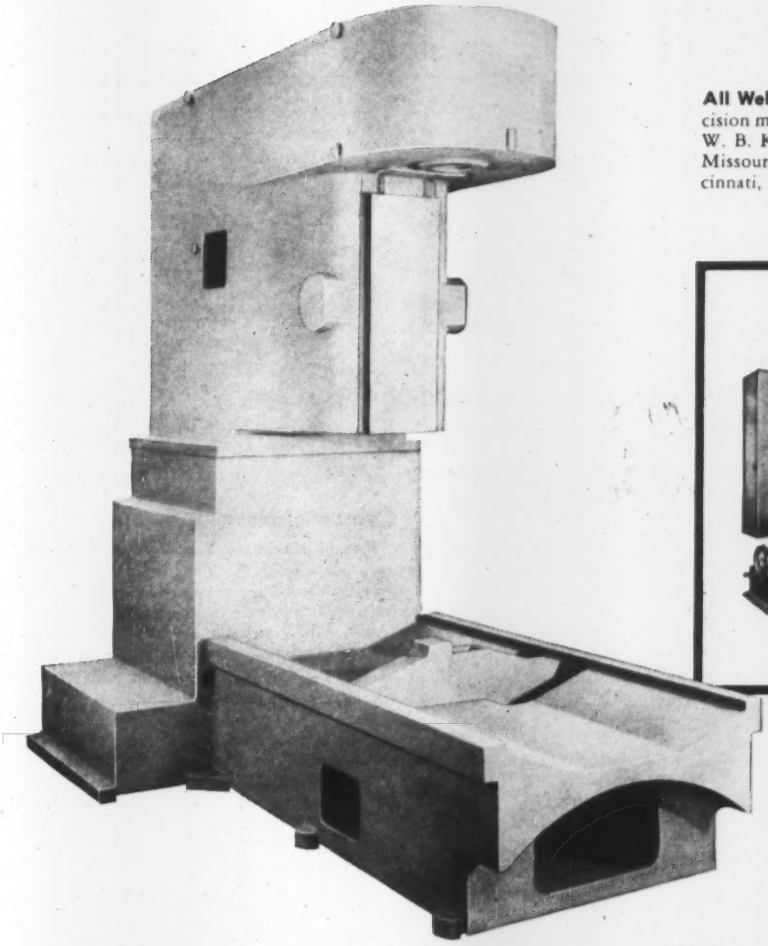
These typical examples demonstrate, first, the big potential output of a relatively small, inexpensive Yoder standardized Slitting Line and, secondly, its big profitability. Assume production of only 35 tons of slit strands per 8 hour shift, one day per week, and the total per year would be 1750 tons. Estimating the saving in slitting cost at only one-half cent per lb., the total annual saving would be $17,500.00.

Besides the big convenience of doing your own slitting, such savings will often repay the investment in a few months.

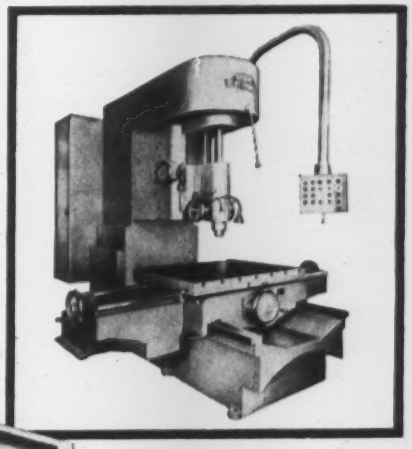
The Yoder Slitter Book **is a comprehensive treatise on slitter operation and economics, with time studies, cost analyses and other useful data. It is yours for the asking.**

THE YODER COMPANY
5499 Walworth Avenue • Cleveland 2, Ohio, U. S. A.

ENGINEERING YODER MANUFACTURING — SLITTING LINES



All Welded Steel Base and Column for precision milling and boring machine. Designed by W. B. Knight Machinery Company, St. Louis, Missouri. Fabricated by Littleford Brothers, Cincinnati, Ohio.



MORE RIGID TO HOLD CLOSER ALIGNMENT

... Welded steel design makes it possible at lower cost

BY proper use of welded steel construction, many types of machines can be built to hold closer alignment and maintain higher tolerances. This is possible because steel is 2½ times as rigid as iron.

Because steel designs use less material, and because steel costs only a third as much per pound as iron, costs can be lowered substantially.

On these precision machines, rigidity for close alignment is combined with modern appearance. Additional savings in cost are possible since patterns and castings are eliminated.

Benefits like these could be duplicated in your designs. Lincoln's 45 years of cost-cutting experience can show you how.

Designers and engineers write for bulletins on designing for steel.

THE LINCOLN ELECTRIC COMPANY

Dept. 4814, Cleveland 17, Ohio

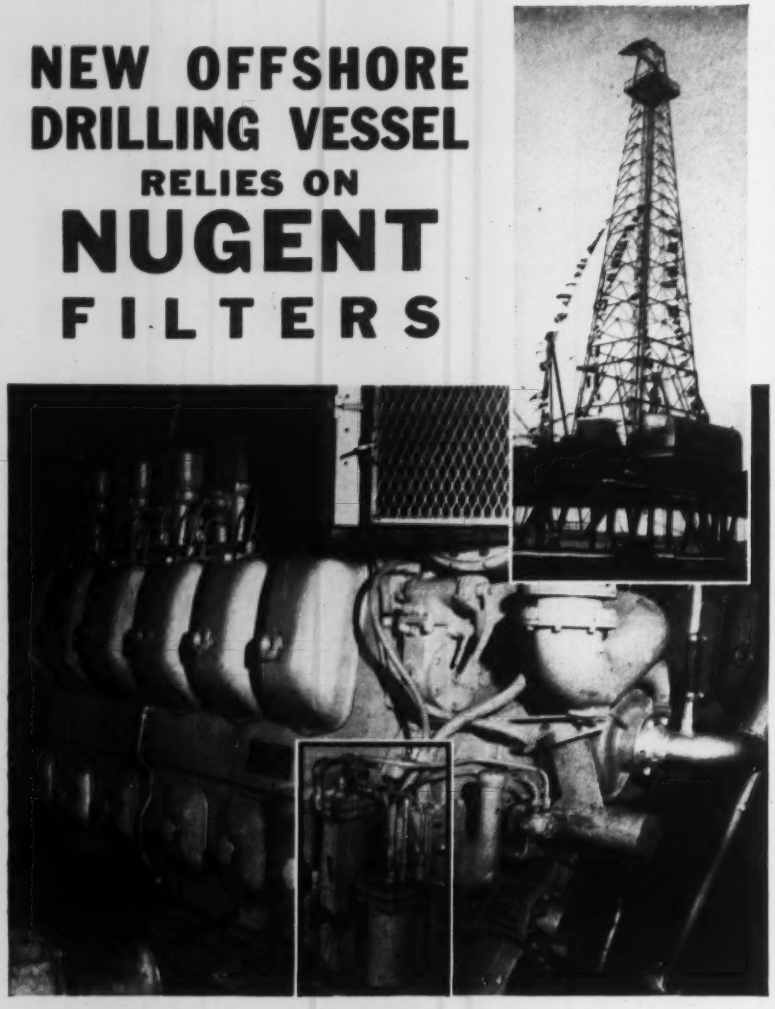
When steel is three times stronger than iron

Has 2½ times the rigidity

Yet costs ⅓ as much

WHY aren't all your products designed for welded steel

NEW OFFSHORE DRILLING VESSEL RELIES ON NUGENT FILTERS



Another new Offshore Drilling Vessel has joined the fast growing fleet of mobile units operating in Gulf of Mexico waters. She's the Delta Offshore No. 1, whose drilling machinery is entirely diesel electric driven. In addition, the three Alco diesel electric generator units making up her main power plant, supply power for air conditioning, lighting and television.

To help guard against costly power failures, Nugent fuel oil filters were selected as original equipment on the Alco Diesels . . . another example of a leading manufacturer providing valuable equipment with the best protection possible.

By removing foreign particles as small as two microns from the fuel supply, Nugent Filters practically eliminate faulty combustion due to clogged injection ports. When employed as lube oil filters, they prevent harmful impurities from reaching vital engine parts, thus greatly increasing engine life.

If you would like to make good equipment better . . . investigate the advantages of Nugent filtering. Descriptive literature available upon request . . . outline your needs . . . we do the rest.

Established 1897

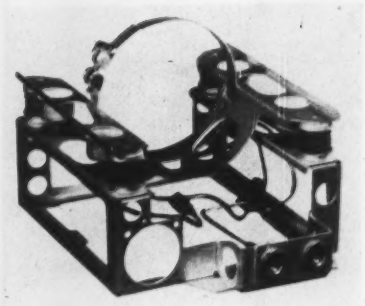
Wm. W. Nugent & Co., Inc.

3412 Cleveland Street Skokie, Illinois

OIL FILTERS, OILING AND FILTERING SYSTEMS, TELESCOPIC OILERS, OILING DEVICES, SIGHT FEED VALVES, FLOW INDICATORS

Representatives in Boston • Cincinnati • Detroit • Houston • Los Angeles • Minneapolis • New Orleans • New York • Philadelphia • Portland, Oregon • San Francisco • Seattle • St. Louis • Tulsa • Representatives in Canada: Montreal • Toronto • Vancouver

KEEP INFORMED — NEW EQUIPMENT, BUSINESS NOTES, LATEST CATALOGS



Transmitter Mounting

Robinson Aviation, Inc., Teterboro, N. J., have developed a Met-L-Flex center-of-gravity mounting for a pressure ratio transmitter unit developed by Minneapolis-Honeywell for airborne applications.

This specialized system incorporates pressure and electrical connectors as part of the supporting structure of the mounting. Constructed of aluminum and steel, the mounting system is described by the company as a permanent type mounting unaffected by adverse operating conditions. The incorporation of resilient elements located in the plane of the center-of-gravity, provides the unit, Model 1323, with environmental tolerance from vibration and shock.

According to the firm, the high percentage of inherent damping displayed by the mounting system results in the reduction of resonant peaks and the quick dissipation of transient forces. The natural frequency of Model 1323 is between 6 to 11 cps while the amount of vibration isolation provided is approximately 90 per cent at 40 cps. It is designed in accordance with military specifications MIL-E-5272A, MIL-C-5541 and QQ-P-416.

High Pressure Cleaner

Instant choice of many different types of cleaning action is said to be one of the prime features of Series "4000" Hypressure Jenny, a new high pressure cleaner announced by Homestead Valve Mfg. Co., Coraopolis, Pa.

By setting valves on the control panel, the operator can get any desired cleaning action ranging from 400 gph of clear cold water at 450 lb pressure, up to a mixture of steam, water and cleaning compound at 325 F., the firm explains. Combinations of heat, pressure, and water volume, with or without cleaning compound, enable the unit to do such diversified jobs as blasting heavy mud or clay deposits from trucks, road-building or construction machinery; removing grease and dirt from equipment, machinery, parts, floors; cleaning for repainting; or doing a thorough job of sanitizing or deodorizing, the company says. The unit is available in portable or stationary models with either electric motor or gasoline engine driven pumps, and a choice of oil or gas for fuel.

Continued on Page 69

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If you would like further engineering information on any of the products advertised in this issue, circle the page numbers of these ads on one of the cards below...fill in your name and address and mail to us.
Your requests will be forwarded to the advertiser. The information will come directly to you.

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1	14–15	29	43	54L	69	77	88–89	107	120	131	141	148BR
2	16	30–31	44	57	71L	78	91	108	121	132	143	149
3	17–18	32	45	58R	71R	79	92	109	122	133	144TL	179
4–5	19	33	46	60TL	72T	80	93	110	123	134	144TR	181
6–7	20–21	34	47	61T	73	81	94–95	111	124	135	145	IBC
8–9	22–23	35	48	63	74L	83	97	112	125	136	146T	OBC
10	24–25	37	49	64L	74R	84T	99	113	127	137	146BL	
11	26	39	51	64R	75R	85L	100	115	128	138	147	
12	27	40	52	65	76T	85R	105	117	129	139	148L	

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4–5	19	33	46	60TL	72T	80	93	110	123	134	144TR	181
6–7	20–21	34	47	61T	73	81	94–95	111	124	135	145	IBC
8–9	22–23	35	48	63	74L	83	97	112	125	136	146T	OBC
10	24–25	37	49	64L	74R	84T	99	113	127	137	146BL	
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PERMIT No. 1144
NEW YORK, N.Y.

BUSINESS REPLY CARD

No postage stamp necessary if mailed in the United States

3c POSTAGE WILL BE PAID BY

MECHANICAL ENGINEERING
29 West 39th Street
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MAIL THIS CARD

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NO POSTAGE REQUIRED

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Aircraft Turnbuckle

A turnbuckle of new design known as the Cabuckle has been announced by Pheoll Mfg. Co., Aviation Div., Los Angeles, Calif.

The unit averages about 1/3 the length of an ordinary turnbuckle of similar capacity and is over 2 1/2 times lighter, the company states. It is made of annodized aluminum and molybdenum steel. Installation is claimed to be easier because the unit never changes length and the amount of take-up remaining is visible at a glance. Predrill holes for short safety wiring are provided.

In operation, balls are swaged on cable ends; one cable end remains stationary while the other end seats on a crosspiece that is adjusted by a nut on the threaded exterior of the sleeve. As the nut is tightened, the crosspiece moves forward and places the desired tension on the cable. Twisting of the cable is said to be eliminated. Baked-on graphite is used as a permanent lubrication to make smooth nut adjustment and prevents position freezing.

While this product was originally developed for the aircraft industry, the firm says it is finding uses in other fields. They are currently available up through 7/32 in. cable capacities and may be ordered in other special lengths, sizes and materials.

Chemical Pump Packing

Abbott and Biddle, 2417-X66-Federal St., Philadelphia 1, Pa., announces its 403, a self-forming chemical resistant packing excellent for emergency use against industrial acids, alkalies, and solvents.

This packing is composed of shredded Teflon combined with suitable binders and lubricants extruded in an open cotton yarn jacket impregnated with graphite. The cotton jacket holds the material for ease of installation. It is also available in bulk form 403S (shredded) that can be used for packing multi-size fittings and applications where the need for rapid assembly prohibits the use of braided or extruded type material.

According to the company, in cases where pure Teflon has failed because of cold flow, lack of resiliency, or compressibility, 403 has shown excellent results. It is serviceable from −150 to +500 F and can be used on all applications (dynamic or static) that require the chemical resistance qualities of this packing, the firm states. The packing is available in sizes 1/4 to 3/4 in. on spools and in bulk form in 1 lb cans.

FIGHT VIBRATION WITH VIBRATION

New twist in testing ...a torsional exciter

TORSIONAL testing *has* been done with rectilinear motion shakers by applying ingenuity in linking table to specimen. But here's a new MB exciter that produces torque *directly*. Its performance characteristics permit you to use it as a *calibrator* for torsional pickups and accelerometers . . . as well as for testing gyros and relays (as examples), or checking torsional vibrations of armatures, or determining torsional modes in various rotating parts.

OPERATING FACTS

At free-table, no load, this MB Model CA 1050 Exciter oscillates at up to 1600 cps without resonance in moving elements. It develops 110 ft. lbs torque, which produces angular accelerations as high as 1570 radians/sec/sec. Maximum total displacement is 45.°

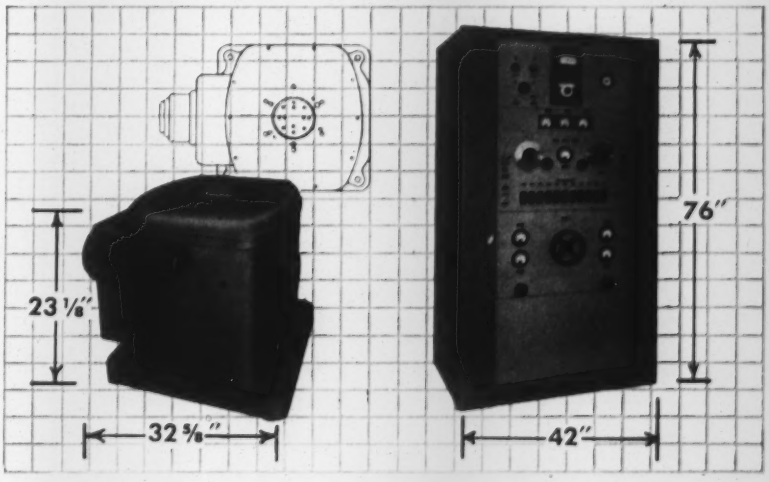
A MATCHED SYSTEM

Any one of several MB electronic power supplies drives the equipment, depending on the specific frequency range, power, and performance you want. The MB Model T51 Power Supply shown comes with automatic cycling controls if desired.

SEND FOR DETAILS

Technical data available. And for more information on how and where to use this unusual equipment, contact our staff of vibration specialists. You can't come to a better qualified authority on the subject . . . nor to one more willing to help on your specific vibration testing problems.

MB *manufacturing company*
A DIVISION OF TEXTRON INC.
1074 State Street, New Haven 11, Conn.
HEADQUARTERS FOR PRODUCTS TO ISOLATE . . . EXCITE . . . AND MEASURE VIBRATION



ENGINEERS, *Electronic & Mechanical*
PHYSICISTS:

Melpar's Dynamic Growth Creates

UNCOMMON OPPORTUNITIES

Melpar has doubled in size every 24 months during the past 11 years. This continuous growth, combined with our policy of individual recognition and organization into small project teams, creates opportunities uncommon to the industry.

As a Melpar staff member you will benefit from our policy of *individual recognition*, which means that your rate of advancement is determined solely by your skill and ability.

Our technical staff is organized into *small project teams*, each of which is assigned a specific problem and responsibility to carry through from conception to completion of prototype. Following a problem through research, design, development, and testing will give you the diversified background necessary to occupy high managerial positions.

In addition, the project team system gives more freedom to your creative talents and enables us to quickly recognize your achievements. These factors should be of particular interest to the engineer or physicist stymied by the complexity of a larger company.

Our ultra-modern laboratory is located on a 44-acre wooded tract in Fairfax County, Virginia. Here you can enjoy a relaxed suburban life with a full quota of golf, sailing, riding and other sports. The Nation's Capital with its renowned cultural and educational advantages is 10 miles away. Attractive housing is available traffic-free minutes from the laboratory.

* *Complete company benefit program including financial assistance for study.*
* *Liberal travel and moving allowances.*
* *Qualified applicants will be invited to inspect the Laboratory at Company expense.*

OPENINGS EXIST IN THESE FIELDS:

Flight Simulators. Radar and Countermeasures. Network Theory. Systems Evaluation. Microwave Techniques. Analog & Digital Computers. Magnetic Tape Handling. UHF, VHF, or SHF Receivers. Packaging Electronic Equipment. Pulse Circuitry. Microwave Filters. Servo-mechanisms. Subminiaturization. Electro-Mechanical Design. Small Mechanisms. Quality Control & Test Engineering. Field Engineering. Antenna Design.

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Technical Personnel Representative

MELPAR *Incorporated*
A Subsidiary of Westinghouse Air Brake Company

3012 Arlington Boulevard, Falls Church, Va.
10 miles from Washington, D.C.

KEEP INFORMED — NEW EQUIPMENT, BUSINESS NOTES, LATEST CATALOGS

Vacuum Metallizing Units

A complete redesign of the vacuum pumping system of its Model 427 72-in. large-scale production vacuum metallizing unit has been carried out by High Vacuum Equipment Div., F. J. Stokes Corp., 5500 Tabor Rd., Philadelphia 20, Pa.

The new design achieves faster evacuation of the chamber and hence permits shorter metallizing cycles and greater productivity, the firm states. Simplification of the pumping system through the use of fewer but larger capacity diffusion pumps is designed to eliminate certain vacuum valves and connections, reduces piping, and improves overall production efficiency.

The redesigned unit has two 16-in. Ring-Jet diffusion pumps of greater overall capacity than the three 14-in. pumps in the former design. The 6-in. booster pump which backs up the diffusion pumps has significantly higher throughput than the booster previously used.

As a result, pump-down time to 0.5 microns (normal "flashing" pressure) has been reduced to 6 min or less and the pumping system is better able to handle unusual operating conditions such as heavy outgassing from the work or from contaminated chamber walls, the company reports.

Reproduction Machine

Ozalid Div., General Aniline and Film Corp., Binghamton, N. Y., announces a new machine, known as the "Streamliner 200," claimed to be the first machine to bring the benefits of a modern, large-capacity model to the low-priced field.

The unit is a compact table model printer which will reproduce drawings, tracings and other material up to 42 in. in width. The machine uses no stencils, inks or negatives and there is no limit to the number of copies which can be made, the firm states.

The machine is 22 in. high and 27 in. deep.

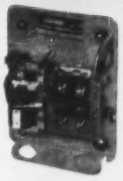
Tape Recorders

Modular electronic assemblies and tape-transport design improvements have been combined in a new series of moderate-cost instrumentation tape recorders developed by Ampex Corp., 934 Charter St., Redwood City, Calif.

According to the company, from one to seven tracks of data may be recorded and reproduced at four tape speeds with its new Series FR1100 equipment. Plug-in record and reproduce amplifiers provide interchange between direct, frequency modulation and pulse-width modulation recording modes. Record and reproduce heads in FR1100 equipment are compatible with all three modes, eliminating head changes when switching from one method to another, the company says.

Frequency response of the FR1100 extends from dc to 100 kc. Direct recording may be used from 300 cycles to 100 kc, and the dc to 10,000-cycle range may be recorded with

MERCOID®
MERCURY SWITCH
RELAYS



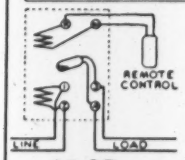
FOR VOLTAGES TO 440 ac or dc

NO SPRINGS OR CLAPPERS

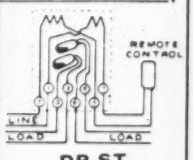
NO WELDING OF CONTACTS
NO MAINTENANCE REQUIRED

The operation of a Mercoid Transformer-Relay has several advantages over clapper type relays. In principle, it is a low voltage transformer—the two coils of which, operate as a repulsion relay.
The primary coil is fixed in position and connected across the high voltage line. The secondary coil is movable and is connected to the control circuit.
When the control circuit is closed, the secondary coil instantly moves upward by repulsion action, thereby operating the hermetically sealed mercury contact. When the control circuit opens, the secondary coil drops by gravity restoring the mercury contact to its original position.

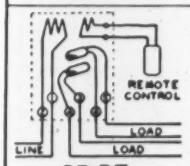
Hundreds of circuit arrangements are available—a few typical examples are shown below:



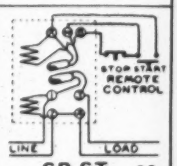
SP-ST
ac



DP-ST
dc



SP-DT
ac

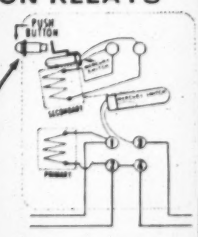


SP-ST ac
start-stop

PUSH BUTTON RELAYS

Available for various circuit arrangements.

Push button to open circuit when relay is energized (circuit will automatically close when relay is de-energized.)



WRITE FOR BULLETIN NO. 31

THE MERCOID CORPORATION
4211 Belmont Ave., Chicago 41, Ill.

KEEP INFORMED — NEW EQUIPMENT · BUSINESS NOTES · LATEST CATALOGS

frequency-modulation methods. Pulse-width-modulated signals from 50 microseconds to 10,000 microseconds may be recorded within ±2 microseconds.

FR1100 transports are built for either 1/4- or 1/2-in. tape on 10½-in. reels, with optional speed ranges of 7½, 15, 30 and 60 in. per second, or 3¾, 7½, 15 and 30 ips. The firm says uniformity of tape motion, necessary for low flutter and wow characteristics, is achieved through new structural design in the transport.

All important components for tape movement are mounted on a single rigid casting for exact alignment of heads, supply and takeup reels, idlers and guides. When special needs require head changes, plug-in provisions insure quick, automatic alignment.

Dry Air Pump

Model 133218 positive displacement dry air pump incorporates patented features at tips and ends of impellers said to provide practically zero clearance without rubbing has been developed by Pesco Products Div., Borg-Warner Corp., 24700 North Miles Rd., Bedford, Ohio.

This oil-free air pump weighs only 5 lb, 10 oz. It is rated at 40 cfm zero pressure delivery or 30 cfm (free air) 10 psi delivery at 7500 rpm. Higher pressures can be attained, and pump speed can be increased if more flow is desired, the company says. The pump may be driven by any suitable means.

Hydraulic Jack

Western Railroad Supply Co., 2400-2434 S. Ashland Ave., Chicago 8, Ill., has added a 100-ton two-speed hydraulic model to the line it purchased recently from the Buda Div., Allis-Chalmers Mfg. Co.

The Model 100B-12 is rated at 100 tons with a lifting height of 6⅛ in. It is recommended by the company as an ideal jack for handling such loads as found in erection of heavy equipment, machinery moving, and bridge building.

To permit rapid engagement of the load, this jack is equipped with a tandem pump. By actuating both high-speed and high-lift plungers, the operator brings the ram in contact with the load. Using the high-lift plunger alone, the load is then lifted. Dual release valves in the base can be operated from either side. The jack base is drilled and tapped for a pressure gage, an optional extra-cost feature.

Oil Pipeline Anchor

An improved welding neck anchor forging has been introduced by Tube Turns, 224 E. Broadway, Louisville 1, Ky. It is designed to anchor high pressure oil and gas pipelines.

The forging takes the form of a double hubbed flange with no bolt holes, which may employ a bearing plate to distribute the load. According to the company, the hubs, of the straight taper type recently adopted

For clean, accurate, dependable heat
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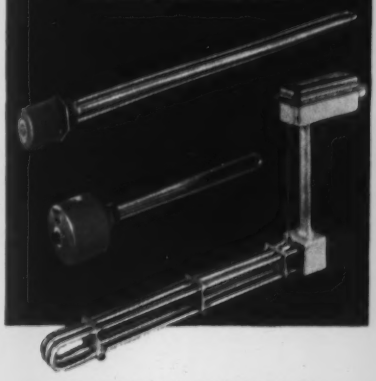


CHECK THESE 5 BIG FEATURES

- **Portable, screw-plug, flanged types; full range of sizes and ratings**
- **"Packaged" units—heating element and thermostat in one**
- **Copper, steel, alloy or lead sheath**
- **Explosion and moisture-resistant terminal boxes available**
- **Most sizes ready NOW for immediate shipment**

For these applications:

Heating water, oils, Dowtherm, Prestone, tars, greases • Plating, cleaning and pickling solutions • Heating tanks, drums, process kettles • Melting greases, asphalt, other viscous fluids • Super-heating steam, compressed air • Melting lead, solder, babbitt and stereotype metal.

FREE CATALOG

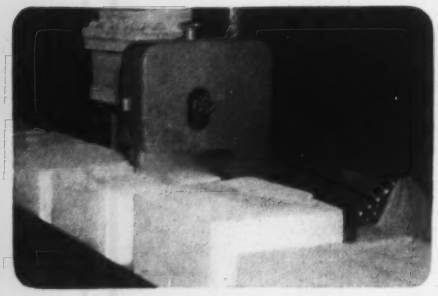
Write today for Catalog 50. Full details including prices for Chromalox Electric Immersion Heaters and other units that provide the electrical answer to many more heating problems.

G-41022A

Edwin L. Wiegand Company
7646 Thomas Boulevard
Pittsburgh 8, Pa.

FRICK

Compressors Make Dry Ice With New Economy



The Colorado CO_2 Corp. produces up to 50 tons of solid carbon dioxide daily in its $2½-million plant near Las Animas, Colo.

The gas, obtained from wells 5 miles away, is condensed, subcooled, and solidified at 109 degrees below zero F. with a new Frick-engineered cycle operating at very economical pressures.

Practically all the mechanical equipment in the plant was furnished and installed by Frick Company. Another example of the COMPLETE engineering service that is yours when you purchase Frick air conditioning, ice making, quick freezing or other refrigerating equipment. Let us quote you now on your requirements.

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Work with the top men, in the most Versatile Laboratories and with the finest test, research and development facilities. New plant being added in suburban Milwaukee as part of Major, Permanent, Expansion Program.

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THE ELECTRONICS DIVISION
GENERAL MOTORS CORP.
Flint 2, Mich. Milwaukee 2, Wis.

KEEP INFORMED — NEW EQUIPMENT, BUSINESS NOTES, LATEST CATALOGS

by MSS for large diameter pipe line flanges, are butt welded to the pipe where it is to be held immobile, and the assembly is buried in a reinforced concrete block of suitable dimensions.

The forging is produced in any of the materials customarily used for flanges. It is available in sizes to match any pipe dimensions, and for the usual pressure conditions, the company reports. In each instance, it is manufactured to meet specific installation requirements.

BUSINESS NOTES

Moves Offices

The engineering, sales and general offices of Bigelow-Liptak Corp., have been moved to new, company-owned quarters at 13300 Puritan Ave., Detroit 27, Mich. The company's new building is air conditioned, has more than 14,000 sq ft of floor space. The firm produces furnace enclosures for industrial applications.

Plant Expansion Program

The recently-completed $500,000.00 addition to the Rust-Oleum Corp. plant, at 2425 Oakton St., in suburban Evanston, Ill., marks the eighth company expansion project within the past ten years. According to the firm, the plant expansion program just completed will double present plant output needed to meet increasing demands for the company's rust preventive products.

Air conditioned throughout, the new addition includes 11,000 sq ft of office space in the administrative buildings and 10,560 sq ft of space added to the manufacturing plants, bringing the total under-roof square footage to nearly 100,000 sq ft.

Opens Allentown Branch

Opening of a branch office by Allis-Chalmers Industries Group at 508 Turner St., Allentown, Pa., has been announced. The new office is a branch of the Philadelphia district and will serve Berks, Lehigh and Northampton counties in Pennsylvania.

Properties of Steam at High Pressures

This is an interim steam table covering a range from 5500 to 10,000 psi and 32 to 1600 degrees F. It is published to provide a reasonable extrapolation of the current tables that will be useful in power systems calculations until an authoritative steam table has been published—five years hence.

1956 $1.00 20% Discount to ASME members

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
29 W. 39th St., New York 18, N. Y.

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Purchases New Plant

Streeter-Amet Co., announces the purchase of a new plant situated on a 14-acre tract in Grayslake, Ill. The new building will contain the executive offices and manufacturing divisions of the company. This will include the Traficounting equipment section, scientific counting instrument section, and the scale sections.

Instrument Gage Division

A new instrument gage division has been established by Taft-Peirce Mfg. Co., Woonsocket, R. I. Taft-Peirce first entered the instrument gaging field in 1947. An instrument gage department was subsequently organized to increase Taft-Peirce service to industry with a product line of air gaging and related equipment.

To Represent Cleaver-Brooks

J. U. Kaye and Co. has been appointed manufacturers' representative for the sale of Cleaver-Brooks boilers in western Pennsylvania, eastern Ohio, West Virginia and two counties in Maryland.

Opens Detroit Office

Peabody Engineering Corp., New York, N. Y., manufacturers of fuel burning, air heating and gas scrubbing equipment, has announced the opening of a Michigan office at 7338 Woodward Ave., Detroit.

Completes Transfer

Baldwin-Lima-Hamilton Corp. has completed transfer of the manufacturing and sales operations of its hydraulic and compacting press department from the Eddystone Div., near Philadelphia to the Hamilton Div., Hamilton, Ohio. The operations have been integrated with those of the mechanical press department which has always been in Hamilton. The hydraulic press department is now in normal production.

Forms Nuclear Division

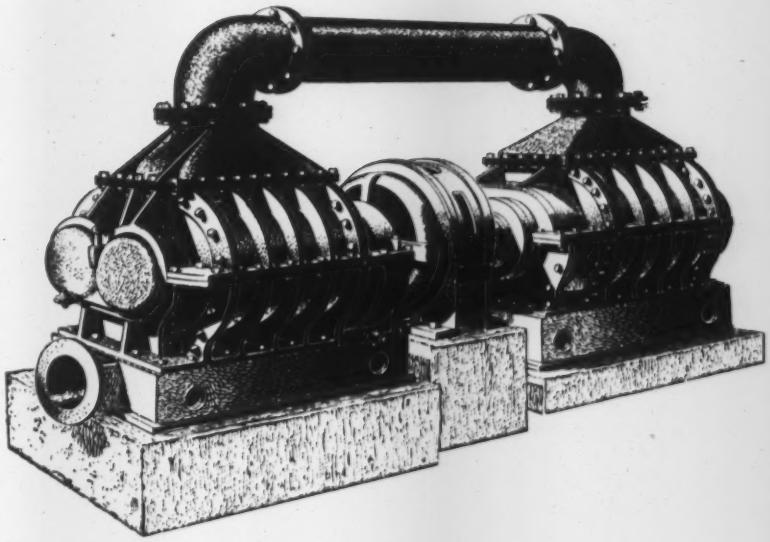
Formation of a new Nuclear Power Equipment Div. has been announced by Kieley & Mueller, Inc., Middletown, N. Y., manufacturer of automatic control valves, power and steam specialty equipment.

The new division is being staffed by specially trained and experienced personnel from both the automatic control and nuclear fields.

To Expand Plant

Raybestos-Manhattan, Inc., announces plans for expanding plant and facilities at its Neenah, Wis. subsidiary plant of Manhattan Rubber Mfg. Co. This expansion will run to $250,000.

The expansion and other improvements will provide increased straight-line production capacity to better service the roll covering requirements of the Fox River and Mid-West areas, the firm reports.



R-C high speed vacuum pumps cost less to install and operate

Outstanding performance over many years in hundreds of applications in paper and other process industries have built a strong preference for Roots-Connersville vacuum pumps.

- Reduced horsepower at higher speeds (600 rpm and up) saves as much as 25% in power and lowers the cost of motors.
- Minimum sealing water required, from 4 to 40 gpm. Performance is unaffected by water temperature.
- Straight spur gears permit operation without axial thrust, reducing maintenance and holding downtime to a minimum.
- Internal parts readily accessible for inspection without disturbing impeller clearances.
- Compact units require small floor space and less expensive foundations.

R-C vacuum pumps are supplied in single-stage or compound units to meet any capacity requirement. For specification data, write for Bulletin 50-B-13.

Engineers—unusual career opportunities await you at Roots-Connersville. Address your resume to Professional Employment Manager.

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A DIVISION OF DRESSER INDUSTRIES, INC.

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A Job For A TWO-HEADED MONSTER

Wm. H. Lagree

PLANT SUPERINTENDENT, THE CINCINNATI GEAR CO.

Some of the men here look on me, I'm sure, as a modern Simon Legree with a nine-foot bullwhip — which isn't really a true picture at all. In fact, I think I'm pretty easy to get along with.

But there are times when I think this job of plant superintendent calls for someone with the attributes and physical characteristics of a two-headed monster. To keep track of a couple hundred different men, working on almost as many different jobs and different machines, all involving a high degree of skill and exacting accuracy, requires something more than mere attentiveness to duty. It means I have to constantly put forth an *extra* effort to do a top-notch job.

Not that I'm trying to brag about myself; my job is tough and sometimes it seems thankless, but it has its compensations. And one of the most important of these compensations is the satisfaction of knowing that my efforts are not being wasted. Because *everyone else* here is "putting out" to do *his* part too, with the result that we have a top-notch Company turning out a top-notch product — something that our customers have come to expect from us as a matter of course.

THE CINCINNATI GEAR CO.
CINCINNATI 27, OHIO
Fifty Years of "Gears—Good Gears Only"

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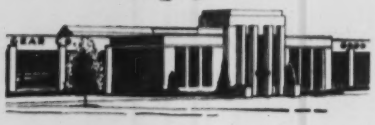

KEEP INFORMED

NEW EQUIPMENT
BUSINESS NOTES
LATEST CATALOGS

Consolidates Affiliate

Detectolab, Inc., a Chicago, Ill., affiliate of Borg-Warner Corp., has been consolidated into BJ Electronics, Borg-Warner's electronics division located at Santa Ana, Calif.

The firm manufactures four major types of nuclear instruments including reactor control devices for government, industrial and aircraft installations, basic research tools for atomic laboratories, tracer instruments for medical diagnosis, and personnel protection devices for monitoring radiation in laboratories and plants.

LATEST CATALOGS

Vapor Thermometers

Jas. P. Marsh Corp., 1121 Rockwell St., Houston, Tex., has released catalog No. 76-T, which illustrates and describes its rigid stem and distant reading vapor tension thermometers.

Included in the 28-page catalog are tables of sizes and ranges, pattern diagrams and detailed descriptions of the various sizes and types available.

Temperature Control

Burling Instrument Co., 16 River Rd., Chatham, N. J., has issued a descriptive bulletin, 106, covering its Model L-1S temperature control.

Included are descriptions of its differential expansion operation and specifications giving temperature ranges, tube sizes, and accuracy. The firm says this model may be used in either liquids or gases and for temperatures up to 1000 F.

Phenolic Products

General Electric Company's entire product line of phenolic molding materials and resins is described in an illustrated brochure, CDC-322, issued recently by the Chemical Materials Dept., Pittsfield, Mass.

The 12-page catolog includes detailed technical data, special properties and product features of phenolic molding powders, rubber phenolic molding powders phenolic laminating varnishes, and industrial and foundry resins.

Conveyor Lubricators

An eight-page catalog that describes new models of the 100 Series and 700 Series automatic conveyor lubricators, has been released by J. N. Fauver Co., Inc., 49 W. Hancock, Detroit 1, Mich.

Mechanism of the 100 series is completely enclosed in non-porous aluminum housing and the units have improved crown filters and regulators as standard equipment. A redesigned trip-mechanism actuates a Hunt valve through a cam.

THESE VALVES control

surge pressures silently

Center-guided type for lines from 1" to 10".

Globe-type for lines from 3" to 24".

WILLIAMS·HAGER
FLANGED
Silent
CHECK VALVES

Surge pressures . . . and the resulting water hammer . . . are effectively controlled by these valves. Protection for pumps and piping systems is assured—a fact testified to by satisfactory service in every type of industry over a period of 28 years, in pressures up to 5,000 pounds.

Write for Bulletins:
No. 654 on the Valves
No. 851 on Cause, Effect and Control of Water Hammer

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Mechanical, Electromechanical

The Johns Hopkins University
Applied Physics Laboratory

ANNOUNCES

. . . important openings on our guided missile research and development staff for men who wish to identify themselves with an organization whose prime purpose is scientific advancement.

Because the Applied Physics Laboratory (APL) exists to make rapid strides in science and technology, staff members require and receive freedom to inquire, to experiment, to pursue tangential paths of thought. Such freedoms are responsible for findings that frequently touch off a chain reaction of creativity throughout the organization. As a staff member of APL you will be encouraged to determine your own goals and to set your own working schedule. You will also associate with leaders in many fields, all bent on solving problems of exceptional scope and complexity.

Equidistant between Baltimore, Md., and Washington, D. C., our new laboratory allows staff members to enjoy suburban or urban living and the rich cultural, educational and research facilities offered by both cities.

Openings Exist in
These Fields:

DESIGN: *Airframes and structures; hydraulic and power supply systems; servomechanisms; launching and handling equipment; ramjet engines; warheads.*

ANALYSIS: *Stress; weights and loads; heat transfer; dynamics; warheads.*

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APPLIED PHYSICS LABORATORY
8607 Georgia Avenue
Silver Spring, Maryland

KEEP INFORMED — NEW EQUIPMENT · BUSINESS NOTES · LATEST CATALOGS

Air Measurement

General Scientific Equipment Co., 7516 Limekiln Pike, Philadelphia 50, Pa., announces the availability of Bulletin No. 138, illustrating and describing gas pressure manometers, oil flow graduates, sling psychrometers, air velocity meters, filter gages, recording thermometers, carbon monoxide detectors, kits for testing gas heating equipment, CO^2 indicators, smoke testers, draft gages, flue gas thermometers, pressure point testers.

Spray Type Desuperheater

A four-page brochure describing design, installation, and typical application of the firm's high capacity, fast-acting spray type steam desuperheater is available from Bailey Meter Co., 1050 Ivanhoe Rd., Cleveland 10, Ohio. It is designated Product Specification M55-1.

Roll Neck Bearings

A 24-page illustrated catalog released by SKF Industries, Inc., Dept. 616, Front St. and Erie Ave., Philadelphia 32, Pa. Contains engineering and technical data on multi-row cylindrical roller bearings designed for heavy-duty service in roll neck mountings on all types of hot and cold rolling mills.

Stainless Steel Fasteners

A 12 page catalog of stainless steel 'AN' fasteners has been made available by All-metal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N. Y. It describes government specification aircraft bolts, slotted and Phillips machine screws, flat and round rivets, and washers carried in stock. Illustrations, stock sizes, principal dimensions, and explanation of part and dash numbers are included for each item.

Steel Tubing, Fittings

H-P Products, Inc., Louisville, Ohio, has announced Bulletin V-157, describing steel tubing and fittings for vacuum systems and conveying lines.

The six-page folder contains drawings of various units and gives specifications and dimensions. Included are elbows, tube plugs, tees, short nipples, reducing couplings, slip couplings, band hangers, male and female adapters.

Aircraft Switches

Micro Switch, Freeport, Ill., a Div., of Minneapolis-Honeywell Regulator Co., has published a new catalog on aircraft switches, Catalog 78.

The 32-page booklet, covers the firm's line of phenolic encased aircraft switches as well as small, metal-covered hermetically sealed switches and high-temperature switches. Switches are shown in a variety of actuator designs, terminal structures and contact arrangements, including single-pole double-throw, double-pole double-throw, double-break, two-circuit, four-circuit and split.

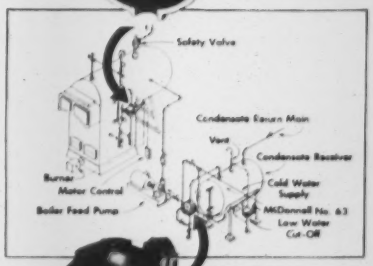
Here's the Great Combination for those...

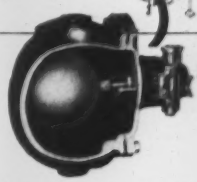
Medium Pressure Boilers
(up to 150 lbs. psi.)

The No. 150 controls the boiler feed pump the one right way—directly from the boiler water level. Holds boiler level within close limits to assure maximum steaming efficiency and fuel economy. Has extra switch which provides circuits for cutting off burner and sounding alarm in case of low water emergency. It's the most widely-used, time-proved control of its kind.

Underwriters Listed

McDONNELL No. 150 PUMP CONTROL





McDONNELL No. 27T MAKE-UP FEEDER

Adds water to condensate receiving tank whenever necessary to make up for any deficiency in returns. Large feeding capacity meets any sudden boiler demand for water. Needle and seat are stainless steel assuring powerful drip-tight closure. For tank pressures to 35 psi., supply pressures to 100 lbs.

Write for simple installation and wiring diagrams

McDONNELL & MILLER, INC.
3510 N. Spaulding Ave., Chicago 18, Ill.

Pioneers Over Thirty Years

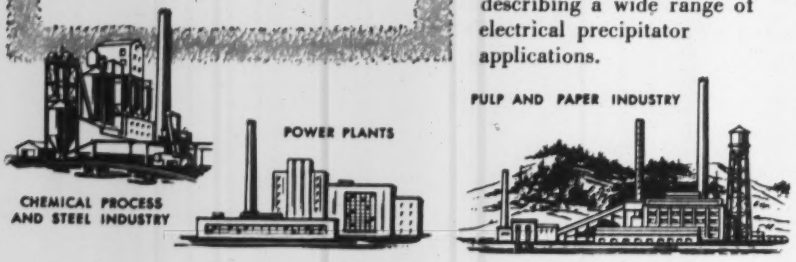
McDONNELL
Boiler Water Level Control and Safety Devices

Industry looks to

RESEARCH -COTTRELL

for high dust collection efficiencies

To maintain visually clean stacks at all times, industry is turning to the long experience of Research-Cottrell in the design and manufacture of highly efficient Cottrell Electrical Precipitators. We've spent 40 years in solving such problems as nuisance abatement, cleaning gas for subsequent use and recovering materials of value. Write for illustrated bulletin describing a wide range of electrical precipitator applications.



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There's a **Ruthman GUSHER** Coolant Pump to fit every requirement

IMMERSED TYPE

Available in 1/10 to 5 HP in either long or short models with separate tank units if desired.

Model 6-P3

PIPE CONNECTED TYPE

Available in ¼ to 5 HP. Easy to install—provides long trouble-free operation.

Model Y-LO

FLANGE MOUNTED (External Discharge)

Available in 1/10 to 5 HP, long or short models. Simple, sturdy design with fewer parts to wear.

Model 11022

FLANGE MOUNTED (Internal Discharge)

Available in 1/10 to 5 HP long or short models. Can be easily and quickly installed in most convenient place.

Model 11027

SHAFT & PULLEY DRIVEN

Gusher Coolant Pumps are also available for installation with shaft coupling or pulley drive, these pumps are supplied without electric motors.

THE RUTHMAN MACHINERY CO.

WRITE FOR CATALOG

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KEEP INFORMED — NEW EQUIPMENT · BUSINESS NOTES · LATEST CATALOGS

Industrial Insulation

Specifications for its complete line of spun mineral wool industrial insulating products are presented in a new catalog published by Baldwin-Hill Co., 500 Breunig Ave., Trenton 2, N. J.

The catalog, which lists standard sizes, thicknesses, and thermal conductivities for more than 20 types of heat and cold insulations for equipment and piping, also includes temperature-thickness recommendations for each. In addition to the characteristics of the materials themselves, the twenty-page, three-color catalog describes typical applications and provides application instructions.

Plastics, Rubber Filler

"Moly-Sulfide as a Filler" is the title of a four-page bulletin issued by Climax Molybdenum Co., Dept. L, 500 Fifth Ave., New York 36, N. Y.

The bulletin describes the uses of Moly-Sulfide—a blue-gray powder, chemically known as molybdenum disulfide—as a filler in nylon, phenolic laminates, Teflon and other plastics, natural and synthetic rubber and asbestos, and outlines the preparation and properties of Moly-Sulfide-filled products as well as the properties of the material itself. Copies of the bulletin, designated Lu-12, are available on request from the company.

Brass Ingot Bars

A new brass and bronze ingot, the "C.P. Process Ingot Bar," is described in a new brochure published by I. Schumann & Co., 4391 Bradley Rd., Cleveland, Ohio. This brochure reviews in detail the advantages of the process which is said to employ radically new methods and apparatus for an additional refining process.

Push Buttons

Furnas Electric Co., 1048 W. McKee St., Batavia, Ill., has issued a 32-page catalog covering oil tight and general purpose push buttons, pilot lights and accessories. The catalog includes description of components and complete units, dimensions, cam action and schematic diagrams.

Wire Partitions

A modern, economical approach to plant layout problems is described and illustrated in an eight-page bulletin on wire partitions and custom enclosures published by Wire and Iron Products Inc., 1725 Sixteenth St., Detroit 16, Mich.

Each panel is a complete unit, interchangeable and movable, and can be quickly assembled and installed by plant workmen. The panels are reusable, and can be disassembled and relocated as plant layout changes require. Also described are custom partitions, developed to meet the requirements of special enclosure and partition applications. Specification data is listed in table form.

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Industrial Lubrication

A 32-page catalog featuring automatic and air-powered industrial lubricating equipment, paint and mastic spray units and accessories has been announced by Gray Company, Inc., 1039 Sibley St., N. E., Minneapolis 13, Minn.

The new No. 403 Catalog illustrates and describes the firm's automatic Gun-Fil bearing lubricators and line of industrial hand and air-powered lubrication equipment, including a new Fire-Ball series high pressure lube supply pumps. Complete units for maintenance and production spraying of paints, mastics and similar materials are also included, together with a wide selection of accessories.

Welding Flux Crushers

A bulletin which describes crushers used by manufacturers to reclaim fused welding flux for reuse has been issued by American Pulverizer Co., 1249 Macklind Ave., St. Louis 10, Mo.

The firm's crushers are also used for crushing laboratory samples, making pilot runs and for the regular reduction of other materials. Capacities of the crushers described range from 600 to 2000 lb per hr, depending on the material and degree of fineness required. Typical installations are illustrated.

Cranking Switches

A catalog sheet, illustrating and describing its new line of magnetic cranking switches, has been released by Leece-Neville Co., 1374 E. 51st St., Cleveland 3, Ohio.

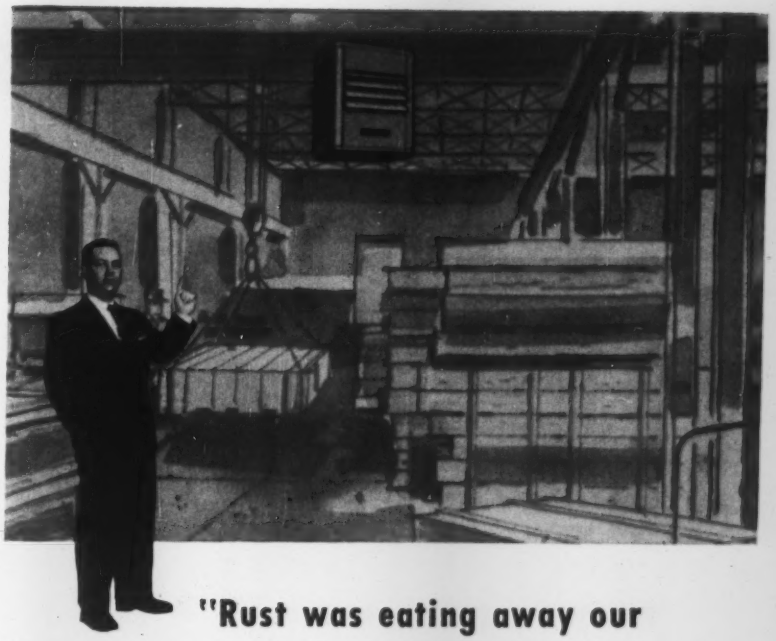
The switches, available in 6, 12, 24 and 32-v models are designed for use on trucks, buses, off-highway units, and industrial and marine equipment with comparable voltage systems. Features of the new models include totally enclosed, waterproof construction; heavy duty, long life contacts, light weight, fast action plunger; nonchattering design; and standard mounting dimensions.

Test Equipment

Various types of environment simulation equipment made-to-order for military suppliers to meet their special test requirements are presented in a new four-page brochure released by the Custom Division of Mantec, Inc., 126 Maryland St., El Segundo, Calif.

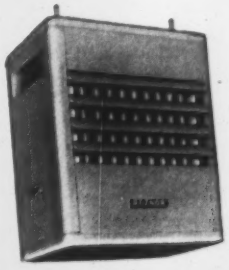
Photographs of the equipment are identified by name of customer, function of equipment and brief technical data pertaining to it. Among the various examples included is a battery of three low temp/humidity chambers designed for a "one shot" series of Grand Central Rocket's third stage rocket motor for the Project Vanguard satellite, and a large, explosion-proof hi/lo temperature chamber designed for B. F. Goodrich Co., Aeronautical Products Div.

For Consulting Engineers Turn to Page 178



"Rust was eating away our warehouse stocks; these Reznor heaters put a stop to it"

"Rust used to be a serious problem at both ends of our production line. It attacked our supply of sheet steel. And it caused trouble in the warehouses where we stockpile our finished products. One way or another rust was costing us thousands of dollars a year; we could have afforded to pay plenty to stop it. But we didn't have to, Reznor gas unit heaters proved to be the efficient, economical answer to our rust problems. We installed a few Reznor heaters in our steel warehouse and a few more here in our finished products warehouse, set the thermostats and forgot them. Rust is no longer a problem. The heaters are no problem, either. Operating costs are lower than we had expected, and maintenance costs have been zero."



Only Reznor Gas Unit Heating Offers All These Advantages

- Low Equipment Cost
- Low Installation Costs
- Low Operating Costs
- Instant Response to Every Change in Temperature
- No Maintenance Problems
- Waste No Floor Space
- Extra Heat for Trouble Spots
- Complete Adaptability to Future Construction

For more information mail the coupon below or call your nearby Reznor distributor. He's listed under "Heaters-Unit" in the yellow pages of your telephone directory.

REZNOR
THE WORLD'S LARGEST SELLING GAS UNIT HEATERS

REZNOR MANUFACTURING COMPANY
71 Union Street, Mercer, Pa.

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☐ Please have a representative call to discuss our plant heating problems.

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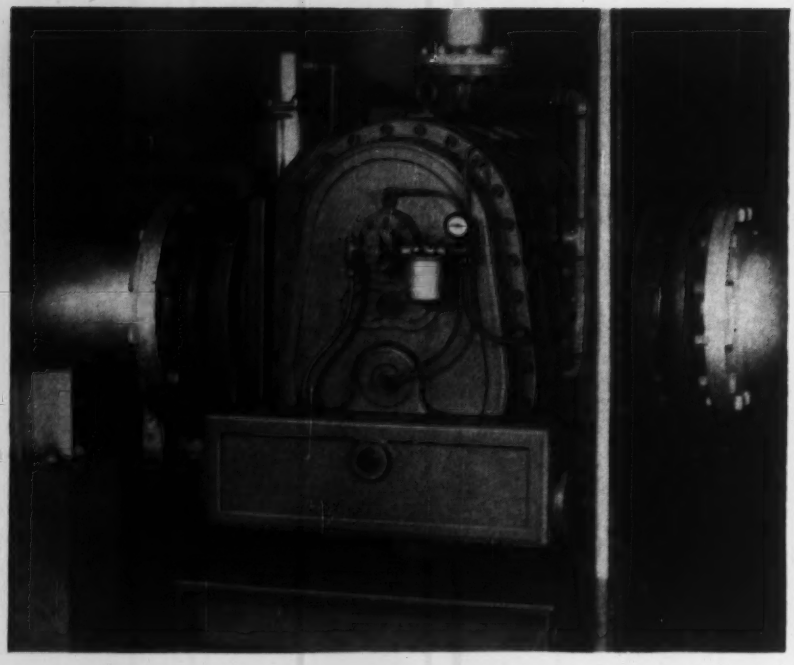
Company.....
Street.....
City..... State.....



4 years of gruelling operation frequently at overload pressures and still no maintenance needed

Since 1951, Standardaire Blowers installed at Spencer Chemical Company have been operating 24 hours a day supplying process air for production of synthetic ammonia.

Although normally operated at 1750 rpm and 8 psig, these units periodically are required to run at more than 50 percent above rated capacity for as long as a month at a time. When brick and catalyst dust seal over reformer catalyst beds, this pressure is needed to force the gases through and avoid costly shutdowns.

After four years of this gruelling, continuous operation, a recent test disclosed virtually no reduction in efficiency of the Standardaire Blowers. They have required no maintenance.

Exclusive cycloidal design and simple, compact construction enable Standardaire Blowers to move more gas or air per pound of blower, with less wear, less maintenance and power consumption. Write for complete information.

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CORPORATION

BLOWER-STOKER DIVISION
370 LEXINGTON AVENUE, NEW YORK 17, NEW YORK

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Plastics Adhesives

An eight-page reprint of a technical paper, "Use of Adhesives With Reinforced Plastics," is available in booklet form on request from Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N. S.

The illustrated booklet, supported by tables, charts, and diagrams, contains data on effect of temperature on tensile shear strengths; physical properties of foamed-in-place plastic "sandwiches"; peel strength of "Kel-F" laminate-to-steel bonds with epoxy room temperature curing adhesives; and bond properties of printed circuit laminates made with various adhesives.

Tube Fittings

Tube & Hose Fittings Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio, has issued a 52-page catalog, No. 4310, presenting its line of Triple-lok tube fittings, made in brass, steel, stainless steel and aluminum. Shapes include a new swivel nut type and straight threaded fittings with o-rings for new SAE straight thread boss.

Air Hammer Catalog

Information about the Ramex air hammer, Model AR-4, featuring precision impact control is contained in a new four-page catalog issued by E. V. Nielsen, Inc., 129 Broad St., Stamford, Conn.

Specifications for this $4^1/_2$-lb hammer capable of 5400 blows per minute as well as specific applications are noted. It is said to have full range control from a light tap to a smashing blow. The unit is chrome plated and features angled air release ports that beam a direct stream of air upon the point of work during operation.

Bushed Roller Chain

Book No. 2454 now being distributed by the Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill., contains a presentation of features of the firm's LXS bushed roller chain.

The chains are manufactured in two designs—straight or offset sidebars—and are supplied with small or large rollers to cover a variety of power transmission or conveyor applications. Nineteen sizes of offset sidebar chains for power transmission applications are available, ranging in pitch from 1.5 to 5 in., with ultimate strength ranges from 8000 to 280,000 lb. A total of 14 straight sidebar chains are available for conveyor service. These chains range in pitch from 1.654 to 6 in. and in ultimate strength from 8000 to 38,000 lb.

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Water Treatment Plants

A technical article on automation of water treatment plants is available from Graver Water Conditioning Co., 216 W. 14th St., New York 11, N. Y.

Technical Reprint T-148 discusses several specific case histories, pointing out the problems involved and the methods of solution. Flow diagrams are shown. Water treatment processes and equipment are divided into three groups—mechanical, chemical, and ion exchange. These are further divided to indicate the many sub-divisions and types of process. The types of measurements required by the processes and the types of control systems are also classified and discussed.

Mobile Pump

A folder covering operating characteristics and applications for its lightweight Porta-Pump line has been released by Barnes Mfg. Co., Mansfield, Ohio.

The folder describes the self-priming as a low-cost, highly mobile unit available with gasoline, electric, or universal drive. It was developed for farm, home, construction, and industrial applications including watering, dewatering, cleaning, spraying, liquid handling and transfer, pressure boosting, and fire protection. Specifications and a pump performance chart are included.

Duct Insulation

Availability of printed data sheets to assist in the writing of insulation specifications for heating and air conditioning duct systems is announced by the Baldwin-Hill Co., of Trenton, N. J., manufacturers of semi-rigid, spun mineral wool duct insulation.

The sheets detail approved specifications for attaching and finishing semi-rigid duct insulation. Three methods of attachment and four finishing techniques are described. Specifications for applying plain, vapor barrier and coated duct insulation are included.

Glass Background

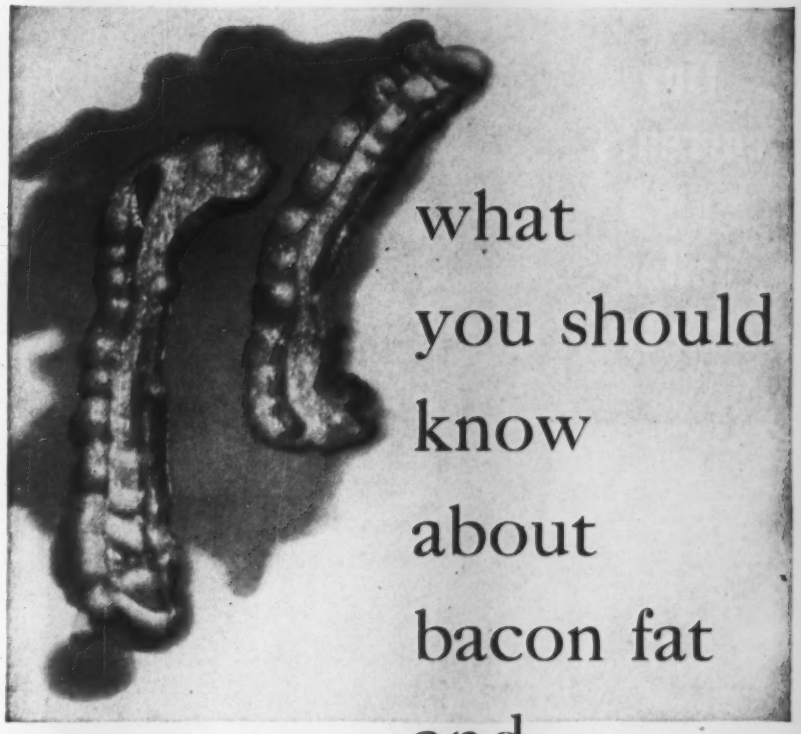
Manufacturing methods, applications, and the history of glass are explained in a brochure entitled "This Is Glass," available from Corning Glass Wks., Corning, N. Y.

The booklet is illustrated with charts, drawings, and 130 photographs.

Refrigeration Units

A bulletin which includes specifications and capacities for open type refrigeration and air conditioning condensing units from $^1/_4$ through 100 hp is offered by Brunner Mfg. Co., 10 Fisher St., Utica, N. Y.

Specifications are included for compressor units for use with evaporative condensers, $^1/_2$-100 hp. Simple compressors in single and two stage for use with horsepower up to 100 are also included. Data and specifications are given for condensing units with Freon-12 or Freon-22 refrigerants in all models.



what you should know about bacon fat and Albanene®

Here's the buying information you should have to get the *best* value when you buy tracing paper.

1. **The usual way** of "transparentizing" tracing papers is with waxes or mineral oils—much the way bacon fat makes a paper towel transparent. Eventually, these oily fluids "leak" out—leaving the paper opaque and useless for reproductions.

   Result: Valuable drawings on ordinary tracing papers eventually become yellow or brittle—lose their reproduction qualities. And, these days, replacements often cost twice as much as the originals.

2. **The K & E way**—Albanene tracing paper is made transparent with an inert synthetic resin which is chemically stable . . . can't leak out—ever!

   Result: Albanene stays transparent . . . stays strong . . . protects every nickel you invest in time and talent working on it.

   Important: During manufacture, constant testing *guarantees* uniformity as well as pencil taking and erasing qualities. The very qualities that have made Albanene—America's best selling tracing paper.

Try Albanene Today . . . it's available in 3 weights and in rolls, sheets or pads. Try it now . . . it's the best value you can buy!

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In equipment and materials for drafting, surveying, reproduction and optical tooling . . . in slide rules and measuring tapes.

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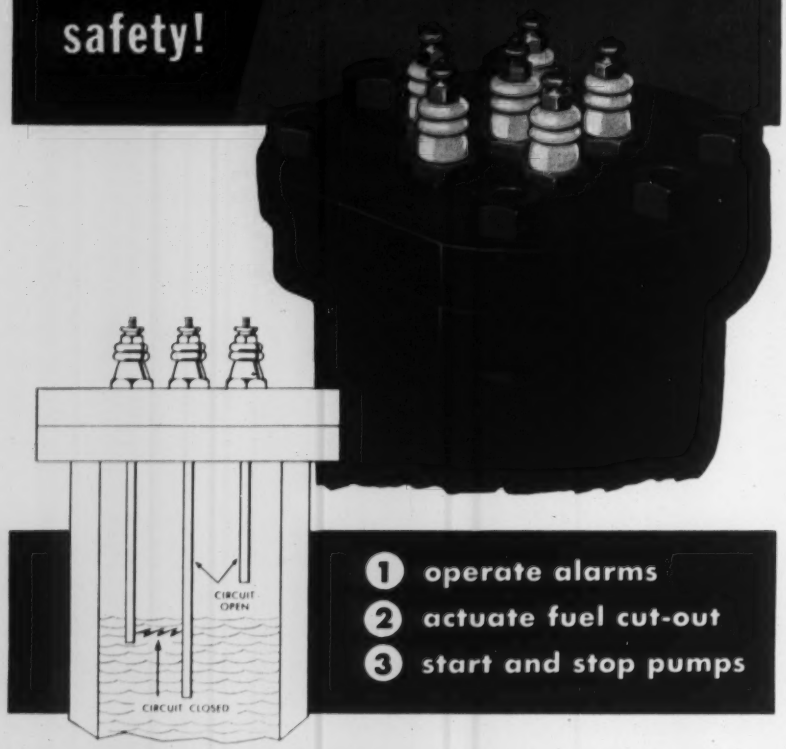
Tiny currents guard boiler safety!

Reliance electrode-type Levalarms



1 operate alarms
2 actuate fuel cut-out
3 start and stop pumps

For extra safety, guard your boiler water levels with audible and visible alarms that reach operators anywhere in the plant. Or cut fuel automatically, without depending on human action. Here's more protection for boilers working on any pressure to 2500 lbs.

Levalarms operate on isolated electric currents passing through the boiler water itself. When water level gets too high or too low, circuits are made or broken and actuate relays *instantly* to cause ACTION (1, 2, or 3 above).

Four models of Levalarms installed on or in your water columns, provide a selection for various control combinations. Levalarms have no bellows or stuffing boxes; no vacuum tubes or magnets. Action is positive, immediate. Levalarms are unaffected by pressure, temperature or water conditions.

Read the full story of Reliance electrode-type Levalarms in Bulletin D2 sent on request.

The Reliance Gauge Column Company • 5902 Carnegie Avenue • Cleveland 3, Ohio

The name that introduced safety water columns....in 1884

Reliance®

BOILER SAFETY DEVICES

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Mechanical Packings

A four-page, 3-color folder listing popular mechanical packings used on all applications in industrial, power, and processing plants is offered by the Mechanical Packing Div., Flexrock Co., 3600-C-Filbert St., Philadelphia 1, Pa.

The company has standardized on the basic packing materials and developed a few all-purpose packings for a wide range of application conditions, the company states.

Screw Conveyor Bearings

A six-page folder, No. 2489, has been published by Link-Belt Co., Dept. PR, Prudential Plaza, Chicago 1, Ill., describing new related ball bearing equipment being added to its screw conveyor component line.

Designed to fit new or existing screw conveyors, the units feature the firm's "Quik-Link" conveyor screw; single and double ball bearing trough ends; new ball bearing hanger; ball and roller bearing enclosed countershaft ends; completely enclosed single reduction helical "Motogear."

Motor Selection

A 12-page, two-color application guide for the selection of electric motors for popular applications has been published by Century Electric Co., 1806 Pine St., St. Louis 3, Mo.

According to Century officials here's how this handy, illustrated manual can be used.

Tables show the kind of equipment or machinery to be driven, and data is given on the character of the load, the speed of operation, starting and running torques, surrounding atmosphere, frame type, and speed.

Rubber Seal Template

Minnesota Rubber & Gasket Co., Minneapolis, Minn. has issued a template-ruler to permit faster and more accurate drawings of the firm's Quad Ring seal.

Five available cross sections—.070, .103, .139, .210 and .275 in.—are cut out of clear styrene plastic to true size and contour. The three smaller sizes have four-times enlearged cutouts below them, while the larger two sizes are stamped out below in twice normal size for scale drawings. Rule sections of the 6-in template-ruler are marked off in eighths and sixteenths of an inch divisions.

PAST EXAMINATIONS
for Professional Engineers given by New York State

This pamphlet contains the questions given in 1952–1956 examinations. They cover problems in structural planning and design, in practical applications of basic engineering sciences, and the more advanced and specialized problems in practical applications of engineering principles and methods.

$2.00 (20% Discount to ASME members)

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
29 W. 39th St., New York 18, N. Y.

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Air Conditioning

Drayer-Hanson Div., National-U. S. Radiator Corp., 3301 Medford St., Los Angeles 63, Calif., has issued 12 pages of engineering data on multizone-type air conditioning equipment.

Designated "Flexazone" engineering manual, the new publication is descriptive of firm's nine-model line of single unit equipment, which via individual zone control, can simultaneously heat one area while cooling another. Cfm's 1752, through 32,250 are available. The publication contains unit nominal rating table and selection and air fraction data. A breakdown of coil capacities and full specification sheet are shown.

Profile Milling Machine

Morey Machinery Co., Inc., 383 Lafayette St., New York 3, N.Y., has available bulletin No. 50M, illustrating and describing its Aeroframe vertical profiler and milling machine.

The unit is designed for machining of ferrous and non-ferrous metals with speeds from 44 to 4800 rpm with 20/40 hp motor. The machine includes a new electro-hydraulic tracing system said to be capable of high tracing speeds and copying with close tolerance aluminum, cast iron, stainless steel, and new high tensile steels.

Fluid Power Pump

A four-page bulletin, No. 46601-B, has been issued by Oilgear Co., 1560 W. Pierce St., Milwaukee 4, Wis., on continuous pressure, constant displacement, heavy duty, types "HG," fluid power pumps.

One of the features of this new series is the availability of a purolator-type micronic filter to provide 100 per cent filtration of the hydraulic fluid just prior to its entrance to the high pressure, axial piston end of the pump, the company reports. Specifications, dimensions, applications, performance data, and suggestions on fluid power systems for pushing, pulling, lifting, lowering, and holding are included on these 3 to 10 hp, 1 to 5 gpm, 3000 to 5000 psi units.

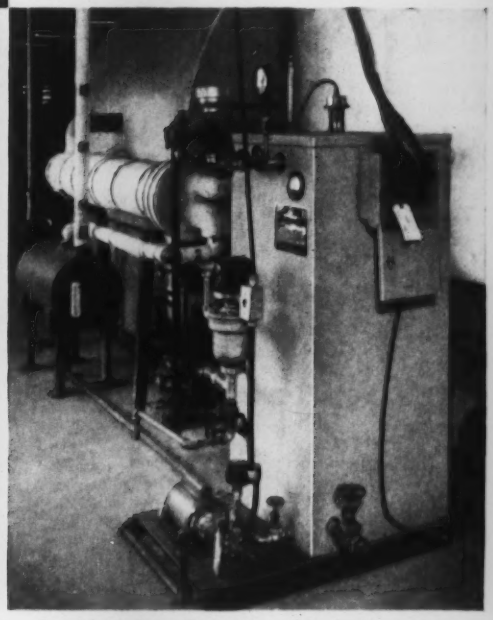
Resin Laminations

A technical bulletin made available by Smooth-On Mfg. Co., 572 Communipaw Ave., Jersey City 4, N. J., describes the system for making glass-laminated epoxy-resin impressions for use in metal working, and model and pattern reproducing. These laminated impressions may be taken from molds, patterns, or mock-ups of plaster, wood, or metal that are used as dies, jigs, checking fixtures, Keller patterns or as molds the company reports.

The bulletin, No. 22 covers preparation of models and describes the actual lay-up procedure from gel coat, through lamination with glass cloth, reinforcement of large impressions, back-up of dies, and final curing. Also included are suggestions for handling, mixing, and weighing, and care of tools and brushes.

Pantex
Speedylectric Steam Generator

Ideal Steam Source for Production Processes



Speedylectric Steam Generator supplying heat to waxer.

Manufacturing huge quantities of waxed paper containers of every size and shape, a nationally-known company needed a reliable source of heat for a production step in which the new containers are deeply impregnated with a special hot wax. Here, as in many manufacturing processes, a Pantex Speedylectric Steam Generator was the answer.

In the impregnation process, accurate control of wax temperature and submersion time is required for dimensional control of the finished product, complete wax penetration and stability of ink colors. The use of a Speedylectric Steam Generator as a heat source not only assures reliable temperature control at modest cost, but eliminates all danger of fire or explosion . . . serious hazards where the plant atmosphere is often full of particles of waxed paper.

Wherever a reliable, convenient, safe source of steam is needed, Speedylectric Steam Generators serve industry. Using a unique electrode method to generate steam, and easily portable, they require no supervision, operate without flame or fumes, and eliminate the risk of fire or explosion.

WRITE TODAY FOR COMPLETE FACTS AND FIGURES

Speedylectric Steam Jet Cleaners, too, serve industry in countless ways. High pressure jet of dry steam and solvents quickly removes grease and dirt accumulations from machines and equipment without flooding floors. No need to stop nearby production or move machines outside. Completely safe and portable.

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Tool Holders

A catalog on the Carmet tool holders and throw-away inserts is being distributed by Allegheny Ludlum Steel Corp., 20th Floor Oliver Bldg., Pittsburgh 22, Pa.

Carmet is the carbide producing facility of the company. The 12-page catalog gives detailed information on this new line of products of tool holders, and throw-away inserts with tables, photographs and drawings.

Standard Storage Tanks

Graver Tank & Mfg. Co., Inc., East Chicago, Ind., announces the availability of a 20-page booklet illustrating and describing standard storage tanks for industrial service.

Numerous installation photos of practically every type of tank are included in the booklet along with specifications of the various tanks.

Scientists ...

Engineers

A message from M. A. Schultz, Project Manager

Westinghouse Commercial Atomic Power

"We are developing the first industry-owned, high-powered Testing Reactor—the *Westinghouse Test Reactor*. It will enable private industry and the government to test materials under conditions of high neutron flux, high temperature and high pressure.

"Here at CAPA, we are continually *pioneering* peacetime atomic power projects. The Westinghouse Testing Reactor is only one of many now under way. Sound interesting? Why not let us tell you more?"

An Experienced, Young, Fast-Growing Team

CAPA—Commercial Atomic Power Activity—is the most dynamic new division at Westinghouse. We're "fluid," not fixed. Supervisory jobs open up fast!

Our growth curve is bound to be *steep*—as electric power demand and atomic power production pyramid sharply. We're entirely *commercial*—not dependent on government contracts. Opportunities for advanced study at company expense. Get in on the "industry of tomorrow" *today*—at Westinghouse CAPA.

Immediate openings

. . . for Physicists • Physical Chemists • Chemical Engineers • Mechanical Engineers • Electrical Engineers • Designers • Metallurgists.

Send résumé to:

C. S. Southard, Westinghouse Commercial Atomic Power, Box 355, Dept. 124, Pittsburgh 30, Penna.

WESTINGHOUSE

FIRST IN ATOMIC POWER

Miniature Bearing

A miniature ball and roller bearing catalog is now available from Landis & Gyr, Inc., 45 W. 45th St., New York 36, N. Y.

The new 16-page catalog lists all of the miniature ball and roller bearings in the RMB line, giving drawings, descriptions, dimension tables, and mounting information. A number of inch dimensioned open and sealed radial bearings are listed in ABEC Class 1 tolerances as well as ABEC Class 5. Two pages are devoted to illustrating applications for each major type.

Low Temperature Apparatus

A 16-page catalog on low temperature apparatus and equipment has been published by Hofman Laboratories, 221 Emmet St., Newark 5, N. J.

New features include liquid oxygen and nitrogen units for "in-plant" transportation and storage; liquid oxygen and nitrogen highway transportation units and vaporizers. Featured also are the standard containers for liquefied gases with accessory equipment; stainless steel dewar flasks; helium solenoid dewars for hall measurements; containers for helium and hydrogen; hydrogen liquefaction and purification dewars and high vacuum oven chambers.

Permanent Magnets

A new 12-page booklet which includes information on permanent magnets, thermistors and Thyrite varistors, under the title of "Trends and Developments for Electrical Design Engineers," has been released by General Electric's Metallurgical Products Dept., Detroit 32, Mich.

The publication, divided into four sections, discusses the subjects in relation to a designer's problems. It points out new approaches, possibilities and methods for using the products. How magnets help designers miniaturize products, determining the proper magnet for a specific application, how thermistors and Thyrite varistors can be "harnessed" for products, are among some of the subjects covered in the publication.

Over-Temperature Thermostat

A direct acting control to protect commercial, laboratory and industrial equipment from exceeding pre-selected temperature limits is described in a bulletin, No. RT-809, offered by Robertshaw-Fulton Controls Co., 110 E. Otterman St., Greensburg, Pa.

The control, available in temperature ranges up to 800 F, will activate automatically when an excessive temperature is reached. Once it is tripped, the cut-out remains in an open position until it is re-set manually. Designated the Model H2, the control is intended for use in electrical equipment only. The four-page booklet contains several diagrams and cut-away drawings about the installation and mechanism of the control.

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15-In. Drill Press

A four-page bulletin, describing the advantages and specifications of a new, heavy-duty, 15-in. drill press, is available from Delta Power Tool Div., Rockwell Mfg. Co., 469 N. Lexington Ave., Pittsburgh 8, Pa.

The bulletin lists the specifications for 40 different models of the new tool—including bench or floor model, high or slow speed, Morse taper or key chuck spindle, single or multiple spindles, and standard or production table models. Components and accessories such as heads, columns and tables for making up special purpose machines are also listed.

Meters, Controllers

Magnetic events-per-unit-time meters and magnetic dual preset controllers are described in two new technical bulletins available on request from Berkeley Div. of Beckman Instruments, Inc., Dept. 2260, 2200 Wright Ave., Richmond 3, Calif.

Both bulletins illustrate the use of Ferristors, small magnetic amplifiers, as vacuum tube replacements. Only tubes used in either instrument are in the RF power supply. Series 7600 magnetic Eputs consist of input amplifiers, a gate opened and closed by a tuning-fork controlled time base, and a series of magnetic decade counting units. Series 5800 preset controllers combine an input circuit, cascaded preset decimal counting units and two identical output channels. Design details and application data are contained in both bulletins.

History of Metal Lath

"History of Metal Lath," a new booklet distributed by the Metal Lath Manufacturers Assn., 636 Engineers Bldg., Cleveland 14, Ohio., treats both the development of metal lath and its modern-day multiple usage.

Including 16 pages of tables and illustrations, the booklet describes metal lath as used in conjunction with accessories, ceilings, centering, ceramic tile, fireproofing, partitions, stucco and vertical furring.

Power Roof Ventilators

An eight-page illustrated catalog, Bulletin 3904, describing the company's redesigned line of power roof ventilators is available from American Blower Corp., Detroit 32, Mich.

The bulletin describes the construction, operation and design features of each of the four models in the improved line. Performance data for 16 sizes of Model VRV upblast type exhaust ventilator, 21 sizes of Model HRV hood type exhaust ventilator and 20 sizes of Model SSV hood type supply ventilator are tabulated. Included are fan speeds and motor horsepower as well as certified delivery ratings up to 1/2 in. w.g static pressure. Also included are intake and duct area values for 5 sizes of Model WSV air intake hood.

Air Compressors

Kellogg Div., American Brake Shoe Co., Rochester 9, N. Y., has published a 20-page catalog covering its line of 1/2 to 20 hp air compressors for automotive and industrial use. The booklet gives specifications on single and two-stage models, portable models, tanks, pumps, and accessories. Charts, data, and information on compressed air are also included.

Conveyor Chains

A new bulletin, 56-60, featuring Rex Table Top conveyor chains has been published by Chain Belt Co., Milwaukee 1, Wis.

The bulletin pictures and describes both steel and nylon chains. Sprockets for the chain are shown and listed, and sections cover conveyor chain engineering and application data, chain lubrication, and conveyor design.

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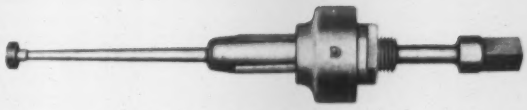
THE QUALITY NAME IN TUBE EXPANDERS . . . SINCE 1892

Tube Expanders for Condensers



No. 255—for average tube sheets

No. 270—for thick or multiple tube sheets

No. 255—Adjustable for sheets up to 2¼" thick

No. 270—Adjustable for sheets up to 7½"

#36

IDEAL

IDEAL Ball Bearing Tube Expanders are made of special analysis alloy tool steels, carefully heat-treated to withstand the severest operating strains. They are adaptable for use with any torque controlled tube rolling units—air, electric or mechanical. *Confidence* is your assurance that your job will be done *RIGHT* . . . when you use WIEDEKE Specialized Tube Expanders, Tube Cutters and Operating Accessories. There is a Wiedeke Distributor in every principal city. For further information write for *new* General Catalog 81.

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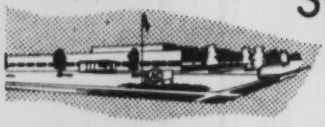
ELECTRICAL MECHANICAL Inertial Guidance System Program



Enjoy Challenging Opportunities in the further development and systems testing of Inertial Guidance Systems and their Servo Loops in the most versatile laboratories in the country.

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KEEP INFORMED — NEW EQUIPMENT · BUSINESS NOTES · LATEST CATALOGS

Tool Limit Switches

Bulletin 956, covering heavy duty limit switches and describing 21 contact arrangements, has been published by the R. B. Denison Mfg. Co., 102 St. Clair Ave., N. W., Cleveland 13, Ohio.

The catalog describes the housing, contact arrangements, wiring diagrams, ampere ratings, operating data and electrical characteristics of each of the firm's nine standard models of Loxswitch limit switches. These include standard universal switches, double pole switches, three pole switches, neutral position switches, and three pole neutral position switches.

Bronze Valves

A four-page folder, Bulletin DH-25, has been released by the R-P&C Valve Div., American Chain & Cable Co., Inc., Reading, Pa. It describes the manufacturer's line of solder end and silverbraze end bronze valves in gate, globe and check designs. Also included are physical characteristics and construction details.

The solder end units are recommended by the company for general full-flow service on steam lines, and on hot and cold-water lines; for copper tubing installations to provide compact assemblies; and for high resistance to rusting and corrosion. The silver-braze end valves are used where vibration, construction, or expansion in a pipe line tends to loosen screwed joints; in confined spaces; to provide leak-proof systems; and for proper alignment and positioning without forcing the joint, the company reports.

Microsized Socket Screws

Microsized Unbrako socket screws, especially designed for electronic equipment, industrial and scientific instruments, and other precisely-built compact products which require small, exceptionally strong fasteners, are the subject of a four-page illustrated folder published by the Standard Pressed Steel Co., Box 558, Jenkintown, Pa.

The folder shows photographs, descriptive drawings and tabular data on threads per inch, length, recommended installation torques, and shipping weight for socket head cap and set screws in sizes from No. 0 to No. 3, either alloy or stainless steel.

Electrical Contacts

A four-page "short-form" catalog published by Gibson Electric Co., 8325 Frankstown Ave., Pittsburgh, Pa., describes materials, properties, forms and uses of the firm's line of electrical contacts.

Discussed in the folder are contacts manufactured from fine silver, palladium and nickel; silver alloys, including coin silver and silver alloys; and many powdered metal compositions designated as Gibsiloys. These are further grouped into ductile, graphite and refractory Gibsiloys. Included are Gibsiloy silver and cadmium-oxide materials introduced last year.

KEEP INFORMED

NEW EQUIPMENT | BUSINESS NOTES | LATEST CATALOGS

Automatic Lubricators

Cyclic-type automatic lubricators driven by the machines they operate are described in a two-color, two page service instruction sheet offered by Bijur Lubricating Corp., 151 W. Passaic St., Rochelle Park, N. J.

This fully automatic lubricator, designated Type N, consists of a piston pump and reservoir. It is pre-set by the machine manufacturer for best operation, and can be adapted to a wide range of metalworking machinery, packaging machinery, machine tools and a variety of special machinery, the company reports.

Machinery Parts

Haynes Stellite Co., 30-20 Thomson Ave., Long Island City 1, N. Y., has issued a new booklet on machinery parts made of alloys. It has been expanded to include data on chemical compositions, physical and mechanical properties, corrosion resistance, and machining of alloy parts.

Separate chapters cover cobalt-base, nickel-base, and iron-base alloys, and typical applications that would fall within each group. Case histories are included to show the use of parts of both standard and special design.

Power Industry Engineering

Sargent & Lundy, Chicago 3, Ill., consulting engineering firm, has published a four-color brochure on the occasion of the firm's 65th anniversary. The 40-page booklet describes the range of services offered to the steam-electric power industry by the firm.

Thirty-three different projects are illustrated and described briefly in the brochure. Included are steam power stations for public utilities, power facilities for industrial concerns, substations and distribution projects, and transmission line work. Also featured is a section dealing with the firm's work in the field of nuclear power engineering.

Pneumatic Transmission System

An eight-page booklet, Bulletin 750, has been prepared by the Simplex Valve & Meter Co., Lancaster, Pa. It describes the Laminair, a form of pneumatic transmission which has been developed to provide a sensitive and accurate type of instrumentation.

The mechanism is designed to produce an output air pressure that varies directly with flow through a venturi tube, flow nozzle or orifice plate, and which may be transferred and used to operate a distant receiving instrument.

Tubular Screen Filter

A brochure describing operations of an automatic, self-cleaning tubular screen vacuum filter is available from Industrial Filtration Co., Dept. FM-200, Lebanon, Ind.

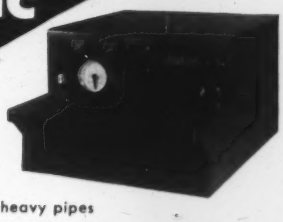
Schematics show filtering and backwash cycles. The units are equipped with conveyor flights for the automatic removal of filtered solids. According to the firm, the units have application in the filtering of coolants, cutting oils, rolling oils, solvents, and all liquids requiring the removal of minute particles. Flow capacities are 5 to 1000 gpm.

Hydraulic Hose Fittings

Reusable Hoze-lok fittings for rubber covered double wire braid hose for high pressure service are described in Catalog 4433, issued by Tube & Hose Fittings Div., Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

The fittings are offered with four different connecting ends: swivel nut for mating with Triple-lok 37-deg flare end connector, male pipe thread, straight thread with o-ring, and 37-deg flare nose. Hose sizes range from $^{3}/_{16}$ through 2 in. ID.

Fairbanks
ELECTRONIC SCALES



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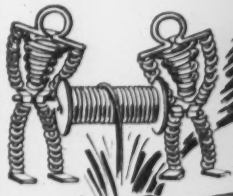

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(PRODUCT OF POWDER METALLURGY)

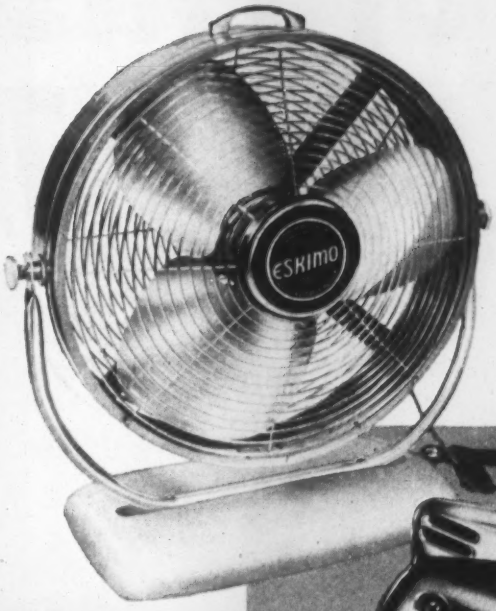
THE SIGN OF A QUALITY COMPONENT

The Gramix label, indicating that a product utilizes one or more Gramix parts or bearings, is helping to boost sales appeal at the point-of-purchase. This seal means that quality components are incorporated in the product. Every day Gramix parts are finding more and more applications. And for good reason: Gramix alloys have excellent bearing and mechanical properties. Because of their porosity, Gramix parts can be impregnated with oil during manufacture, to make them self-lubricating. Gramix bearings and parts are mechanically strong, durable and highly resistant to wear. Gramix parts are equal, and in many cases superior, to machined parts and can be produced in relatively intricate shapes with tolerances as close as .0003″. And best of all, Gramix parts are being produced at a fraction of the cost of forged or machined parts of similar design. It is likely that there is a place for Gramix in your products.

The Gramix label—*available at no cost to you*—comes to you in handy rolls, with adhesive backing, along with an easy-to-use dispenser. Labels can be quickly and easily applied (at final inspection, for instance) giving your product extra sales-appeal for just a few seconds' time spent.

THE UNITED STATES

ADVANTAGE



Modern Eskimo fans, manufactured by the Bersted Manufacturing Division of McGraw Electric Company, Boonville, Missouri, are the result of many years' experience in the manufacture of efficient and dependable appliances. Eskimo fans spin on Gramix bearings and therefore operate hour-after-hour, day-after-day, and year-after-year without fail. Eskimo fans carry the GRAMIX label, for added sales appeal at the point-of-purchase. Write today for your copy of Gramix bulletin No. 21.

The Thor Speed Drill, produced by Speedway Manufacturing Company of Cicero, Ill. (Division of Thor Power Tool Company) gives professional performance yet sells at an "amateur" price. Gramix bearings help contribute to both the high performance and modest cost of these fine tools. The Gramix label assures the user that Speedway power tools are tools of dependability.

These Gramix self-aligning bearings are typical of the type being used in the Eskimo fans and Speedway drills.

Write today for this book. Engineering Bulletin No. 21 gives the full story on Gramix. Be sure to write for your copy.

229

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 4, MICHIGAN

8 YARDS OF PAYLOAD

7,000

WEIGHS 3½ TONS LESS

TRAVELS FASTER

CARRIES MORE PAYLOAD

ADDED! POUNDS SAVED!

High strength-to-weight ratio of USS "T-1" Steel solves difficult design problem

In the past, lightweight materials such as bauxite ore have presented a hauling problem *because* of their light weight. Standard hauling units, designed for heavier materials, had too much dead weight . . . couldn't haul enough volume of lightweight materials. Athey Products Corporation, Chicago, Illinois, has solved the problem with the help of USS "T-1" Steel.

Athey engineers designed a new rear-dump trailer specifically for high-volume lightweight materials. Starting point was a conventional 22.5-cu.-yd. trailer. The high yield strength of USS "T-1" Steel—90,000 psi minimum—enabled them to use much higher design stresses and, thus, reduce the thickness of steel required.

As a result, volumetric capacity of the 22½-cu.-yd. model was boosted to 30½ cu. yds. The new unit weighs just 13 tons—7,000 pounds less than it would if built with low-alloy steel. USS "T-1" Steel's toughness and resistance to impact abrasion give the trailer ruggedness and durability needed in off-road mountain service.

This lighter-weight trailer can travel much faster, when empty, than heavier standard units. As a result, it spends less non-productive time in making empty return trips to the mine. It not only carries more payload, but is hauling payload during more of its total operating time.

Where can you use USS "T-1" Steel?

Consider USS "T-1" Steel where you need an unusually high strength-to-weight ratio. Use it where you need unusual toughness and resistance to impact abrasion at low temperatures . . . where you need good high-temperature strength combined with toughness and resistance to abrasion. Remember, *all* of these properties are combined in USS "T-1" Steel *with good weldability*. Call, wire or write for more information. United States Steel, Pittsburgh 30, Pa.

SEE The United States Steel Hour. It's a full-hour TV program presented every other week by United States Steel. Consult your local newspaper for time and station.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
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USS "T-1" CONSTRUCTIONAL ALLOY STEEL USS

UNITED STATES STEEL

The knowledge and experience **of hundreds of engineers are yours to share through the publications of the ASME. Here are a few such technical aids. For a complete list, send for the 1957 Catalog of Publications.**

1956 TRANSACTIONS OF THE ASME

To be published April 1st $15.00 ($7.50 to ASME members)

It is in this 2500-page book that you will find information that may well point the way to success with your engineering problems. Here, in some 240 carefully prepared articles, are reports of important investigations, surveys of significant trends, accounts of recent technological developments that have been used successfully by other engineers, and a unique collection of factual information and data. Following are some of the subjects dealt with:

Bearings. Beams, Columns, Structures. Buckling. Cavitation. Cooling Systems. Elasticity. Feedwater Treatment. Flow of Fluids. Fluid Meters. Forgings. Gas Turbine Power. Graphical Methods. Heat Exchange Equipment. Heat Transfer. Hydrodynamics. High Temperature Materials. Pressure and Temperature Instruments. Lubricants and Lubrication. Machine Tools. Metal Cutting. Metal Creep, Failure, Forming, and Testing. Nondestructive Testing. Plates and Shells. Plasticity. Pneumatic Drives. Pumps. Outdoor Power Plants. Gas Turbine, Hydraulic, Industrial, Nuclear, and Steam Power Plants. Servomechanisms. Stresses and Strains. Thermal Stresses. Thermodynamics. Turbomachinery. Vibration.

CUMULATIVE INDEX TO ASME TECHNICAL PAPERS

To be published mid-1957 Price not to exceed $20.00

This Index to ASME technical papers published in the Transactions, the Journal of Applied Mechanics and Mechanical Engineering will consist of two sections: The first will cover approximately 3200 papers published in these magazines from 1940 to 1956. Its alphabetical subject index will list the titles of the papers chronologically under as many headings as are necessary and include numerous cross-references to direct attention to related material. Its alphabetically arranged authors' index will give the headings and the year under which each paper is listed in the subject index. The second section will be a reprint of the Sixty-Year (1880–1939) Index originally published in 1940 and now out of print. The size of the volume will be 9" x 12" and the binding, dark blue buckram with title stamped in gold on the spine.

ASME TERMINOLOGY STANDARDS

GLOSSARY OF TERMS IN NUCLEAR SCIENCE AND TECHNOLOGY

1957 Edition to be published March 15th $5.00

This Glossary defines the specialized terms which have arisen with the development of nuclear science. In a single alphabetical listing, it consolidates some 1500 terms and definitions which were originally published in the following separate sections: Physics, Reactor Theory, Reactor Engineering, Chemistry, Chemical Engineering, Biophysics, Radiobiology, Instrumentation, Isotopes Separation, and Metallurgy. While no new terms will be found in this 1957 Edition, it does contain a number of important improvements such as the amplification of some of the definitions, modification of others, the removal of ambiguities in the former edition, and correction of typographical errors.

INDUSTRIAL ENGINEERING TERMINOLOGY

ASME Standard No. 106 1955 $1.50

Industrial engineering covers so many segments of an industry that it has its own peculiar problem of semantics.

This Dictionary is an attempt to define and standardize its terminology. The result of three years of coordinated research, it presents, in its 50-pages, approximately five hundred terms along with definitions that are so clear that they may be understood even by a non-expert in the field. Both the terminology and definitions have also received the approval of some forty practicing management consultants and terminology committees of Canada, Great Britain, South Africa, and the United States.

AUTOMATIC CONTROL TERMINOLOGY

ASME Standard No. 105 1954 $1.50

The terms defined in this Standard apply principally in the fields of automatic control in industrial processes. They cover automatic controllers, basic concepts, processes and their elements and characteristics, characteristics of automatic control, types of automatic controller action, adjustment of automatic controller action, and the elements and characteristics of automatic controllers. Block diagrams of automatic controllers, the feedback loop, and automatic control combination are shown. Symbols for defining the block operations are included, also a brief discussion of the considerations underlying the construction of block diagrams and their associated symbols.

HANDBOOK FOR SMALL SAWMILL OPERATORS (ASME Standard 109) 1957 $3.00

This Manual shows how to attain and maintain accuracy of cutting lumber by indicating some of the causes of miscutting and the action that sawmill operators can take to eliminate them.

CONTENTS: Need for Dimensional Control. Controlling Lumber Thickness. Headrigs. Product Accuracy Affected by Parts of Husk, Ways and Carriage and Inadequate Power. Saws, Their Selection and Fitting. Sawmill Foundations. Installation and Adjustment of Sawmill Equipment. Causes of Poorly Sized Lumber. Causes of Inaccuracy in Edging and Trimming. Mathematical Miscalculations. Glossary of Terms Used Throughout the Manual. Reference Tables.

DIRECTORY OF CONSULTING ENGINEERS To be published March 15th $2.50

This Directory includes ASME members engaged in consulting work and also consulting engineering firms with which such ASME members are associated. The services offered are so varied as to make it possible to locate a consultant or firm of consultants qualified to work out solutions to engineering and management problems encountered in most branches of engineering. The 1200 names and addresses in its pages are arranged geographically with each entry indicating the type of consulting service performed.

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THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS 29 W. 39th Street, New York 18, N. Y.

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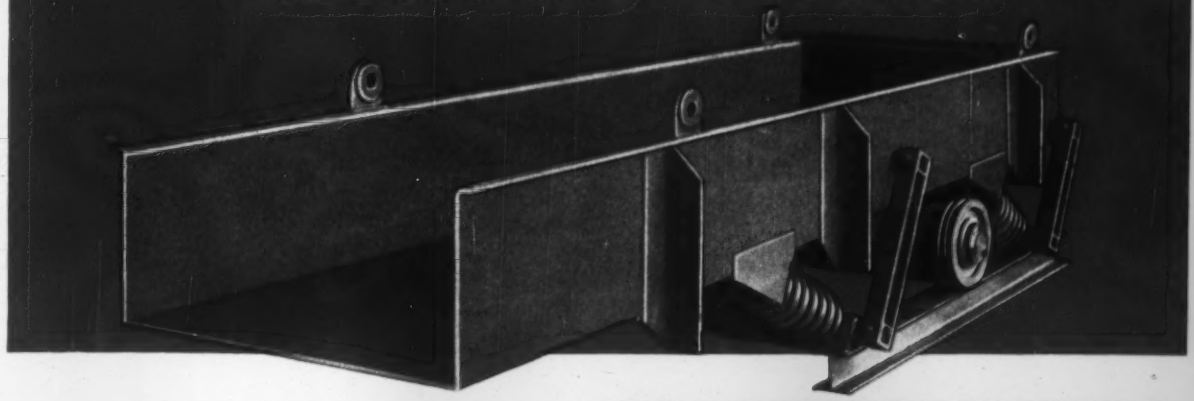
Less Maintenance, Less Downtime With

CARRIER NATURAL-FREQUENCY VIBRATING FEEDERS!



UNLIKE MOST MAGNETIC OR MECHANICAL FEEDERS, Carrier Natural-Frequency Feeders use heavy-duty coil springs *as a source of driving energy!* The springs compress and expand — alternately storing, then giving back the same amount of power to the trough. This exclusive Carrier Natural-Frequency design guarantees low maintenance and less downtime because INPUT HORSEPOWER IS LOW AND DRIVE STRESSES ARE UNIFORMLY DISTRIBUTED!

Furthermore, Carrier Natural-Frequency Feeders have only *four simple operating parts* — trough, heavy-duty coil springs, base member, and motor-driven rotating weight!

As you can see at the right, low maintenance and less downtime are only two of *many* Carrier advantages. Whatever your feeder requirements, chances are a Carrier Natural-Frequency Feeder will do a better job — *and save you money, too!* For full engineering details, write for a copy of our new Bulletin 1001. Carrier Conveyor Corporation, 245 N. Jackson Street, Louisville 2, Ky.

Low Horsepower — Natural - Frequency feeders use less than two-thirds the horsepower of any other type of feeder for the same capacity.

Choice of Lengths— Standard units are 6′, 8′, 10′ or 12′. Greater lengths also available.

Special Designs— Units available with grizzly decks, screen decks, dust-proof covers.

Instantaneous Start-Up — No warm-up period required.

Mechanical Dependability — No complicated electrical system required.

Simple Construction — Stock bearings used throughout.

High Temperature Units—For materials up to 2500°F.

PLUS — Rugged construction . . . easy installation . . . low reaction to supporting structure . . . less damping under load and improved efficiency.

NUCLEAR NEWS FROM ATOMICS INTERNATIONAL

OMR a promising approach to meet world's need for small to large power plants

An important goal of the Atomic Energy Commission's program to develop electric power from the atom is a low-cost reactor for plants with gross outputs of 10 megawatts or more. Such plants are particularly suited to areas that need relatively small increments of additional power, and to those parts of the world where coal, oil, and waterpower are scarce or costly.

The OMRE (Organic Moderated Reactor Experiment), which ATOMICS INTERNATIONAL is now building at the National Reactor Testing Station in Idaho, is one of the more promising types for this purpose. The new experimental reactor was pioneered by ATOMICS INTERNATIONAL – from preliminary design to prototype.

It will be used to investigate the rate of degradation of organic fluids, the properties and compositions of the equilibrium mixture in the reactor, and the effect of organic fluids on heat-transfer surfaces. Results of these experiments will be incorporated into the nuclear power plants ATOMICS INTERNATIONAL is planning for Piqua, Ohio and a Latin American country.

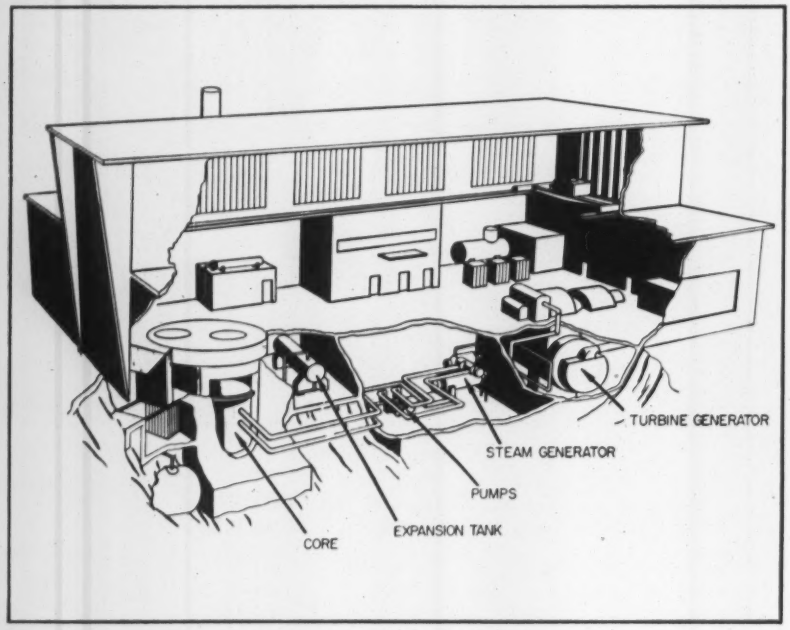
Basic advantages of the OMR are small size, compact core with good neutron economy, and elimination of problems with high-pressure primary coolant circuits and uranium-coolant reaction hazards. Its safety features are outstanding. The high boiling point of the organic moderator-coolant fluid permits a low-pressure system. There are no chemical incompatibilities between coolant and uranium or coolant and water, and no unusual corrosion problems. Because of its fluid moderator—an isomeric terphenyl—the OMR has a negative temperature coefficient of reactivity, which acts as a governor in case of power surges or excess power levels. The organic fluid becomes only slightly radioactive, which makes the entire heat-transfer system relatively accessible.

A typical power plant, such as the one proposed for Piqua, Ohio, has a gross electric output of 12,500 kilowatts and a heat output of 45,500 thermal kilowatts. It produces steam at a pressure of 415 psig (29 kg/cm^2) and a temperature of 550°F (288°C).

The reactor core is heterogeneous, with fuel elements and control rods immersed in the moderator-coolant fluid and contained in a thin-walled core tank. The fuel is uranium slightly enriched in U^{235}.

Power costs for this reactor, including both capital and operating charges, are estimated at 18 mills per kilowatt-hour. Power costs will be significantly lower in larger OMR plants. Lower power costs are also expected to result from advances in OMR technology.

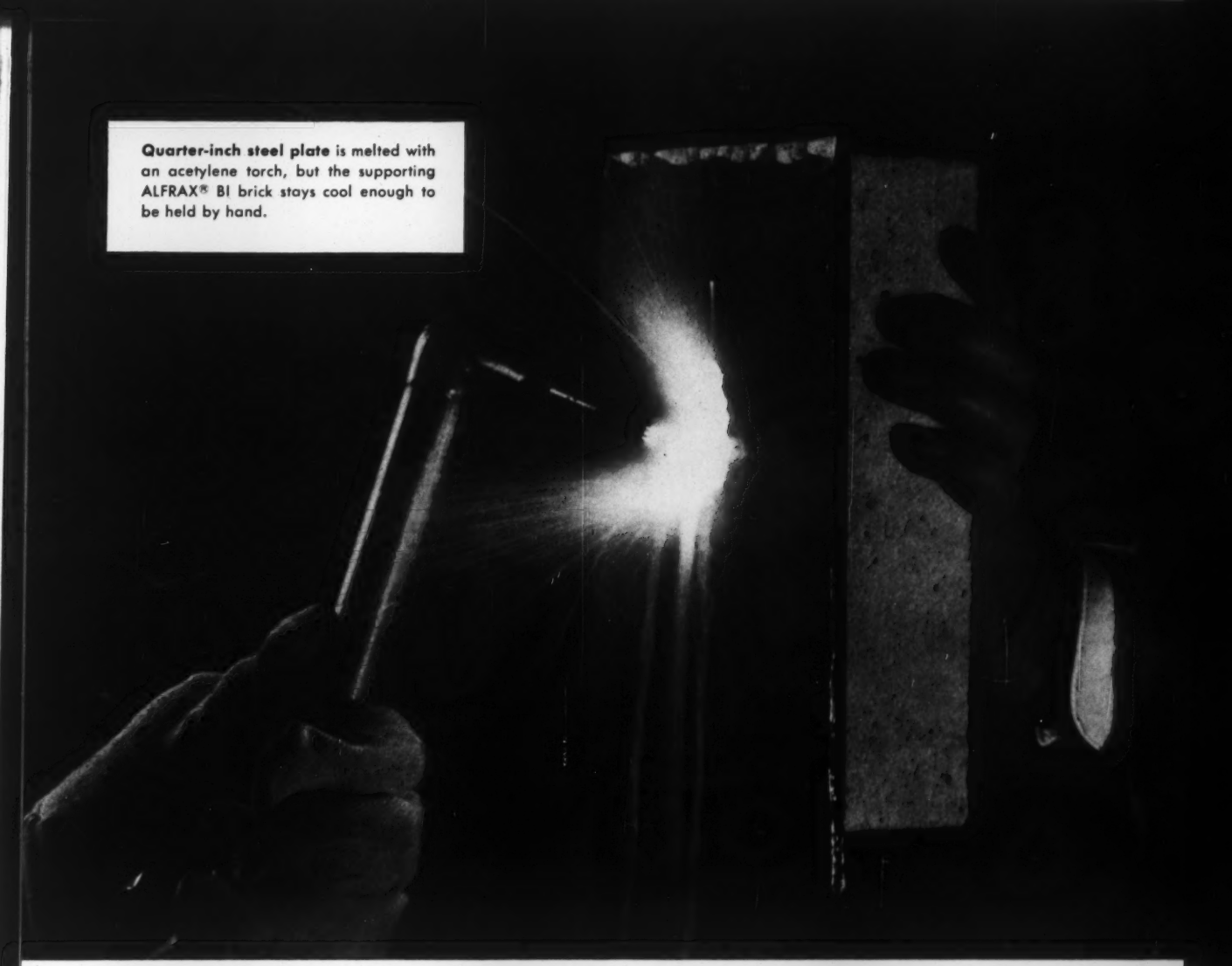
Atomic power for supertankers. The AEC has assigned ATOMICS INTERNATIONAL the challenging design study to adapt the OMR for maritime use. The OMR, considered a promising possibility for ship propulsion, is expected to be particularly suitable for supertankers. The OMR offers the safety of a low-pressure system, low construction costs (because it can be built of aluminum and mild steel instead of more expensive zirconium and stainless steel), and low maintenance costs.



Typical OMR Central Station Nuclear Power Plant

ATOMICS INTERNATIONAL is staffed and equipped to help you with any phase of reactor development. Please write: Director of Technical Sales, Dept. ME-72, ATOMICS INTERNATIONAL, P. O. Box 309, Canoga Park, California. Cable address: ATOMICS.

ATOMICS INTERNATIONAL
A DIVISION OF NORTH AMERICAN AVIATION, INC.
PIONEERS IN THE CREATIVE USE OF THE ATOM



Quarter-inch steel plate is melted with an acetylene torch, but the supporting ALFRAX® BI brick stays cool enough to be held by hand.

Refractories...for really high temperature insulation

The problem of heat insulation at extreme temperatures is solved by two of Carborundum's refractories:

One is made of fused alumina "bubbles" or hollow spheres, bonded and high fired. These selected bubbles give proper balance between the number of surface temperature drops and total pore space (about 65% porosity) to effectively decrease heat flow between hot and cold faces. The alumina imparts high hot strength to the finished refractory, trade-marked ALFRAX BI. Under a load of 12½ psi and a temperature of 2732° F held for 1¾ hrs., less than 1% contraction occurred. No contraction whatever developed in 5 hour reheat tests at 3092° F. This combination of properties makes ALFRAX BI refractories unique in their ability to insulate at temperatures where other materials are impractical.

The other is FIBERFRAX® ceramic fiber, produced by blowing an alumina-silica fusion. Among its properties are high insulating values, light weight, resiliency, and corrosion resistance. All are retained at 2300° F. In some cases, this fiber can be used successfully up to 3000° F. It is supplied in long and short staple, rope, board, paper, block, blanket, etc.

These products are but two of the many super refractories pioneered by Carborundum. Among them you are almost certain to find answers to your refractory and high-temperature problems. For help, fill in and mail this coupon today.

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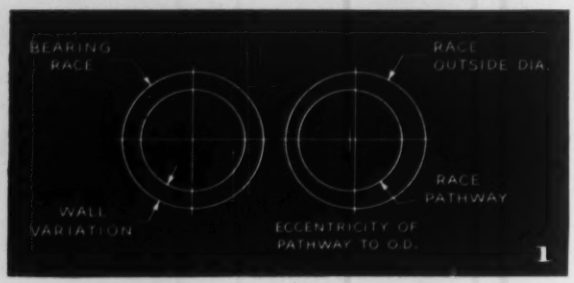
The Inside Secrets of Smoother Performance

How HYATT quality controls assure race concentricity, roller diameter uniformity and other internal essentials of smoother, longer-lived cylindrical roller bearings . . .

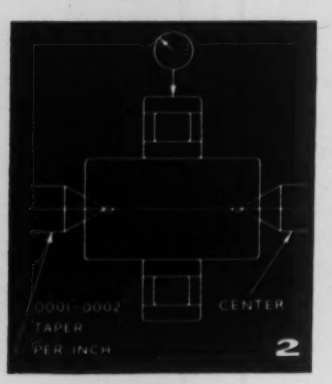
The running accuracy and smoothness of a roller bearing is governed primarily by its internal dimensions and clearances. The most important of these are:

1. CONCENTRICITY OF RACE DIAMETERS

Eccentricity of race diameters is usually interpreted in terms of *wall variation*, Figure 1, on the individual components and in terms of *radial run-out* on the assembled bearing. The



assembled bearing is usually mounted on an arbor, Figure 2, having a slight taper (.0001″ to .0002″ on the diameter per inch of length) and the radial run-out indicated as shown. The radial run-out is the difference between the minimum and maximum readings obtained when rotating the outer race one revolution with the arbor stationary for outer race radial run-out, or rotating the arbor one revolution with the outer race stationary for inner race radial run-out.

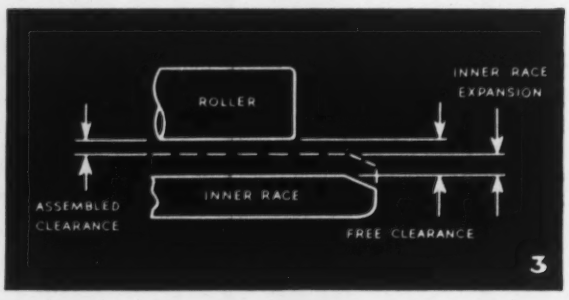


2. UNIFORMITY OF ROLLER DIAMETERS

Another factor governing running smoothness is *roller diameter uniformity*. This is usually obtained by segregating the rollers into diameter variation classes of .00005″, .0001″, or .00015″, depending on the bearing size and the nature of the application, and assembling only rollers of the same group into a given bearing. Gauging for this segregation necessarily rejects excessive taper.

Uniformity of roller diameters is important for another purpose. It provides the user with a bearing in which the internal diametral clearance is controlled within the closest possible limits. The rollers are matched with races which are segregated for pathway size in a fashion similar to the rollers, usually to twice the diameter limits of the rollers. The internal clearance can thus be manipulated at will by combining various diameter classes of races and rollers; but once a particular range is selected, it will remain constant within the combined limits of the roller and race pathway diameter limits. Here, again, a tapered condition of the race pathway is automatically rejected.

Obviously, the internal clearances of commercial bearings must be standardized for the practical reasons of cost and availability, but the clearance values have been so selected that under the specified fits the *running* clearance is at the most desirable minimum, depending on bearing type and size. Figure 3 (magnified).

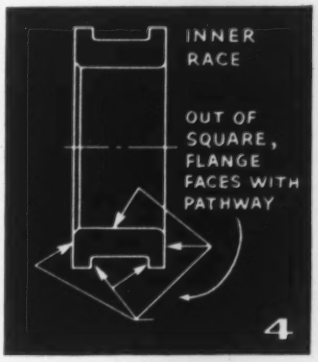


Checking wall variation, flange run-out and race end squareness on combination gauge.

3. SQUARENESS OF ROLLER ENDS AND FLANGE FACES

One other tolerance that contributes to the running efficiency of HYATT Hy-Load Series Bearings of the flanged race type is the *squareness of roller ends with roller diameters* and the *squareness of flange faces with the race pathways.*

Flanged race bearings are commonly used for locating shafts laterally and for running conditions of light and intermittent thrust load. For best operating results, the ends of the rollers must be flat and square with the diameter within a matter of tenths. The lateral clearance between the roller and the race shoulders must also be held to a minimum. This means close tolerances on roller length and race pathway width, and the flange face, Figure 4, must be square with the roller pathway. When all these conditions are satisfied, there will be no tendency for the rollers to skew and raise the operating temperature of the bearing, nor will there be any unusual force on the separator or cage with a tendency toward wracking and noisy operation.



The *side run-out* of the individual races or the *out-of-square* of the ends with the fitting diameters is also important, especially in applications where a number of parts are held together endwise and where the pressure might be sufficient to tilt the race, creating a condition of excessive taper on the roller pathway with consequent roller skewing and the development of excessive heat and noise.

All these internal dimensions and clearances are so carefully controlled that HYATT Hy-Roll Bearings have built an unsurpassed reputation among design engineers for exceptionally long, smooth and trouble-free performance.

YOU WILL FIND MORE DETAILS

in HYATT General Catalog No. 150, or your nearby HYATT Sales Engineer will gladly help you choose the type best suited to your design requirements. Remember, HYATT is America's first and foremost maker of cylindrical roller bearings. Hyatt Bearings Division of General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT HY-ROLL BEARINGS FOR MODERN INDUSTRY

Leadership in Action EBWR

TYPE: Experimental boiling water reactor—designed and built by the Argonne National Laboratory.

POWER: 5000 kilowatts of electrical power capable of supplying most of the Laboratory's requirements.

SIGNIFICANCE: The first of five prototype reactors completed under the AEC developmental program of atomic power for civilian use.

STATUS: Brought to full power in December, 1956.

Argonne
NATIONAL LABORATORY
Operated by the University of Chicago under a contract with the United States Atomic Energy Commission

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At British Columbia Power Comission's Ladore Dam, 96-inch Howell-Bunger valves dissipate energy from a 75-fooot head of free-discharge water. Inverted cones on downstream ends are one-piece Lukens spun heads, a money-saving application.

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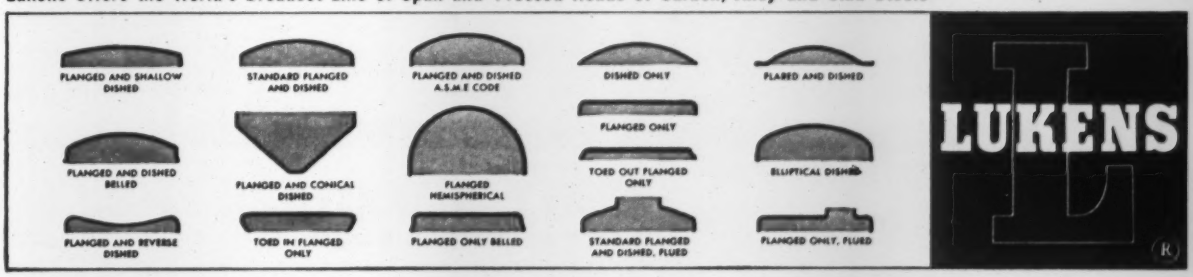
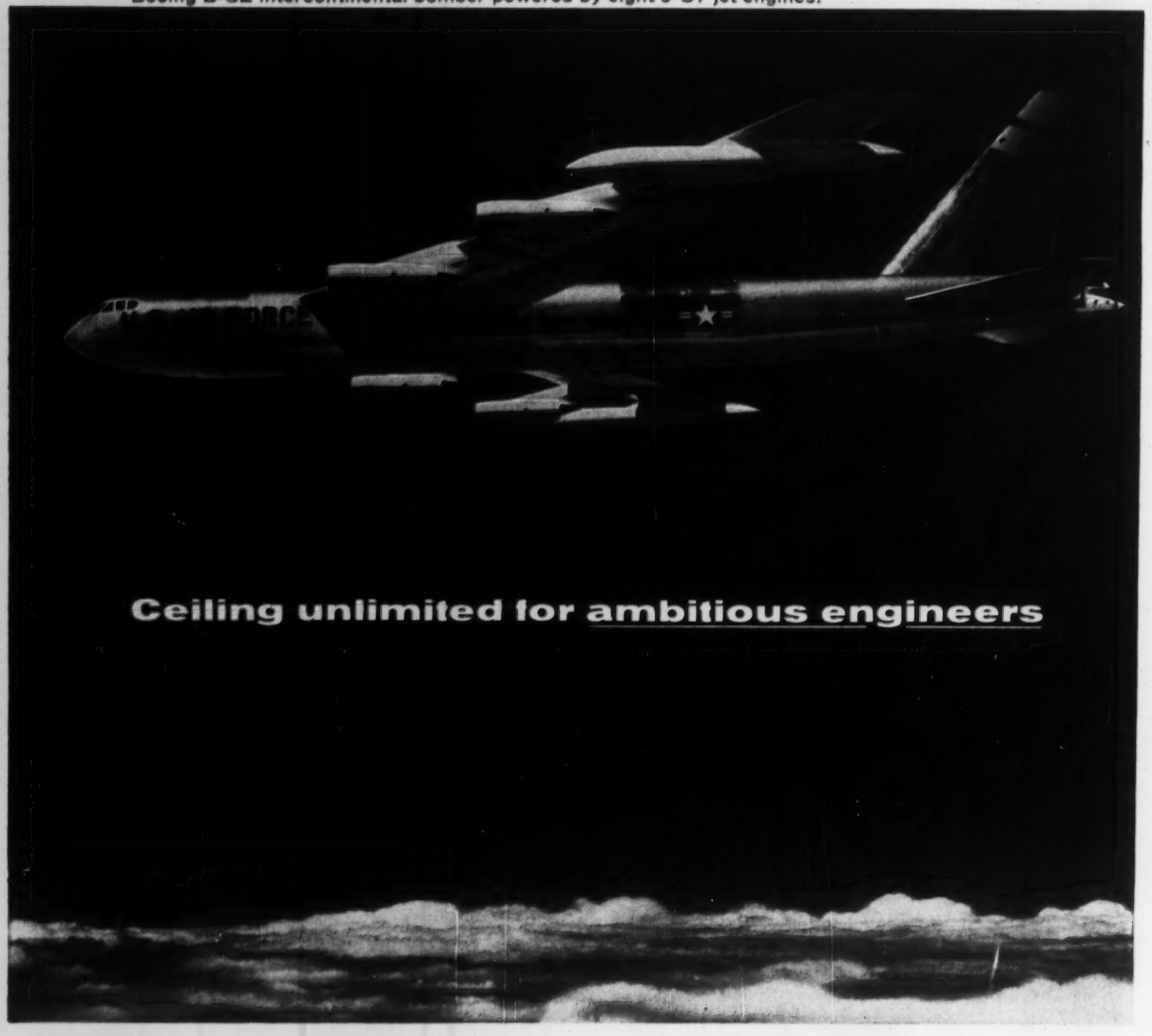
■ Ever think how Lukens standard head shapes might simplify the design of your machinery? Or permit entirely new design? Engineers at S. Morgan Smith, for example, build their huge Howell-Bunger valves using conical Lukens heads at the discharge end. Pre-formed heads reduce design complexity, eliminate costly fabrication steps.

Lukens heads may well improve *your* equipment design, reduce cost. The resources of Lukens' fifty years of leadership in producing heads for many applications are at your service. *Would you like technical details? Write for Catalog 658, "Pricing and Engineering Data," Lukens Steel Company, Coatesville, Pennsylvania.*

Lukens Offers the World's Broadest Line of Spun and Pressed Heads of Carbon, Alloy and Clad Steels



Boeing B-52 intercontinental bomber powered by eight J-57 jet engines.



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Graduate engineers for challenging assignments in the design of turboprop, turbojet and advanced aircraft engines and their components. Experience desirable in compressors, turbines, aerodynamics, hydraulics, gears, valves, bearings, piping, controls, afterburners and related equipment, heat exchangers and combustion problems.

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Work involves the design of mechanical and electrical equipment for experimental testing of aircraft engines and their components. The following are typical of the projects handled by the department: DESIGN of gear box and drive motor installations • DESIGN of blower systems and air piping • LAYOUT of piping systems for water, steam, air, oil, fuel • DESIGN of special jet engine instrumentation • DESIGN of mechanical assemblies — gear boxes, drive shafts, couplings • DESIGN of engine test cells.

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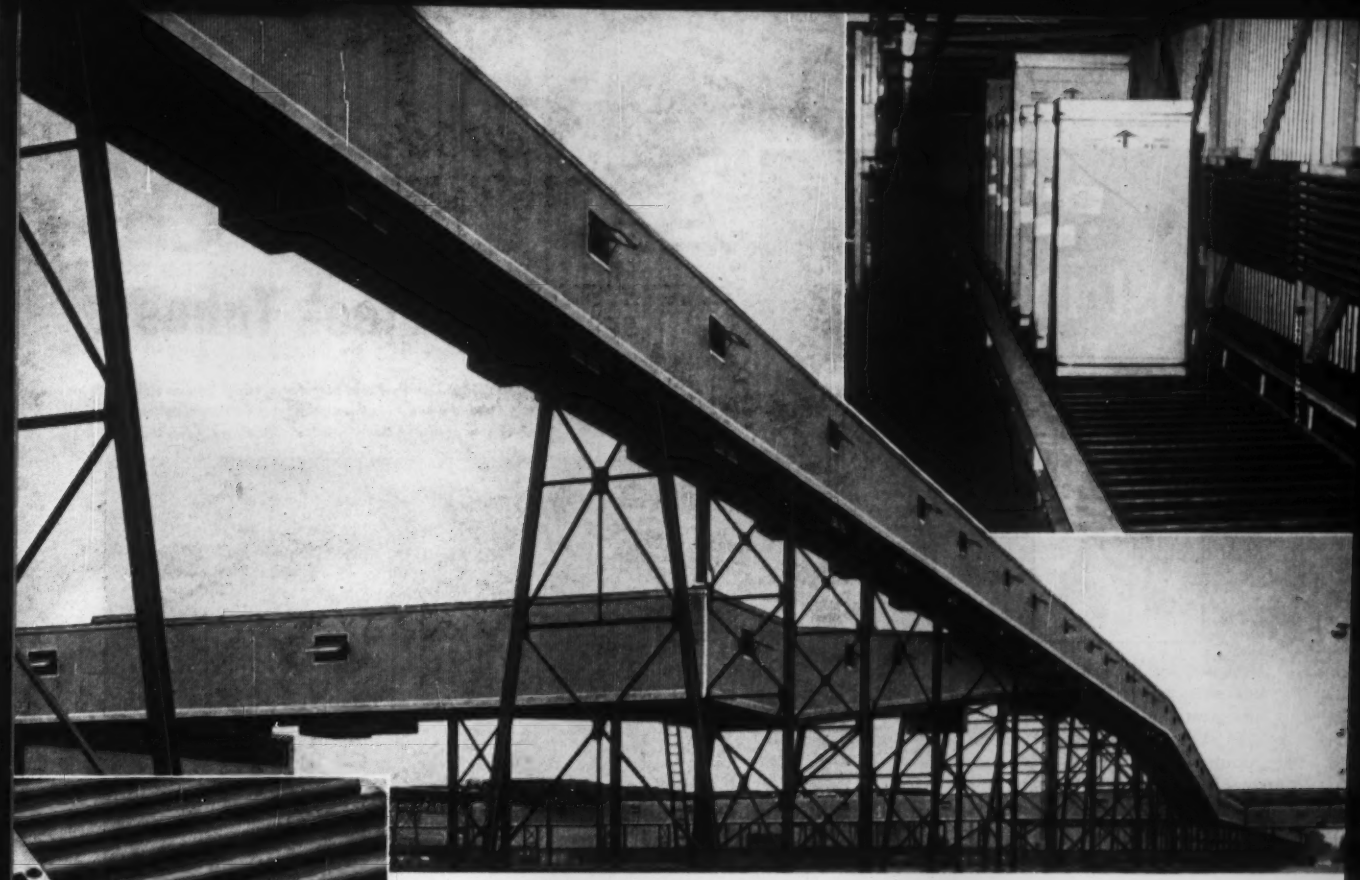

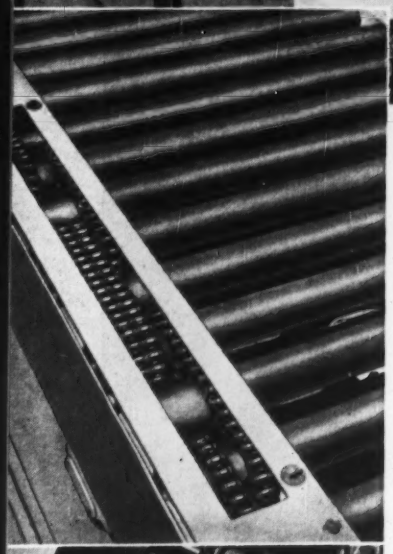

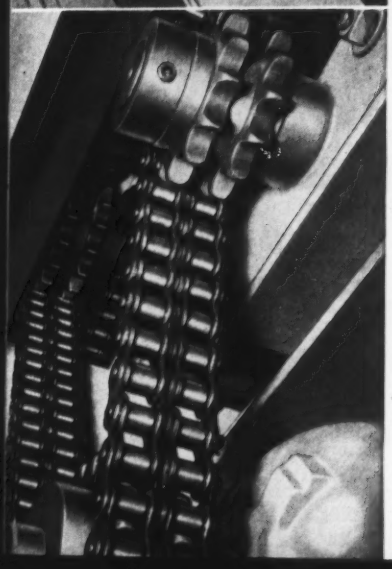

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Five production buildings can feed 1800 products per hour into the overhead conveyor system. The conveyor sorts products into trains, approximately 24′ long, moves them 3,000 feet across the park to a central warehouse and divides into 6 product groups for selected storage or shipping.

This is one more example of Diamond Roller Chain performance, extra economy, long operating life and *dependability* on the job.

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Designed for the cotton industry, this new hydraulic press permits an operational economy which has been called “one of the most important moves in the industry since Eli Whitney invented the cotton gin.”

This press produces high density bales at the cotton gin, eliminating the need for extra compression of standard density bales before export shipment. Cotton bales from this press measure only 21″ x 23″ x 54″.

The first cotton baling press of its size, it operates at a hydraulic pressure of 2,000 psi, and exerts a total force of 1,650,000 pounds. Both of its main hydraulic cylinders were made from 23″ OD Acipco steel tubes.

Because they are centrifugally spun, Acipco steel tubes possess a uniform, highly dense, non-directional grain structure which is easier to machine, yet stronger and tougher. This quality, and others, can mean important economies in your application — both for you, and for your customer. Find out how by calling or writing your nearest Acipco distributor today.

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ANALYSES: All alloy grades in steel and cast iron, including heat and corrosion resistant stainless steels; plain carbon grades and special non-standard analyses.

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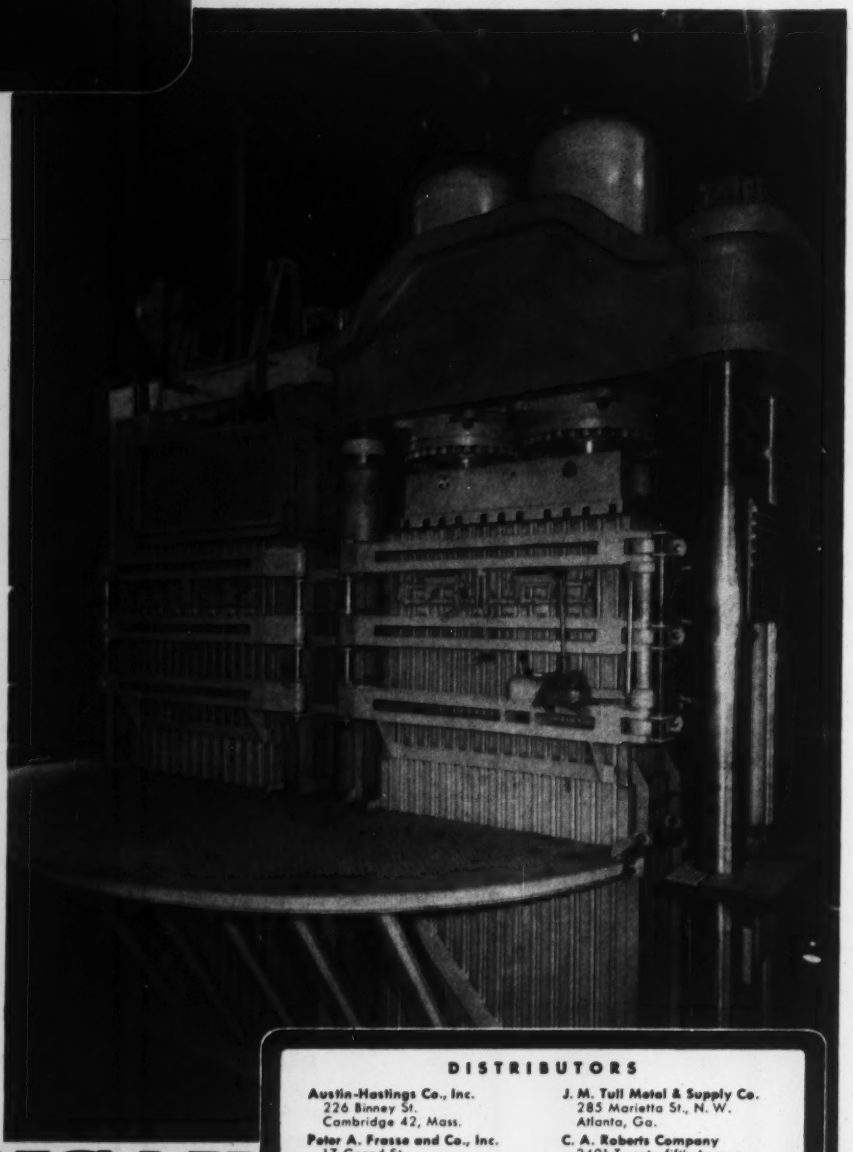
CENTRIFUGALLY SPUN Steel Tubes

“Delta” High Density Press, manufactured by Continental Gin Company of Birmingham, Ala. for a California cotton gin. Photo courtesy Continental Gin Company.



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POSITION:
World's largest manufacturer of aircraft and missile systems.

LOCATIONS:
Santa Monica, El Segundo and Long Beach, California; Tulsa, Oklahoma; Charlotte, North Carolina.

AGE:
37 years in aircraft; 15 in missiles.

EDUCATION:
An engineering company managed by engineers — such as Donald W. Douglas, B.S., Aeronautical Engineering (M.I.T.); F.W. Conant, B.S., Civil Engineering (Cornell); and A. E. Raymond, B.S., Mechanical Engineering (Harvard), M.S., Aeronautical Engineering (M.I.T.), and Ph.D. (Hon.) (Polytechnic Institute of Brooklyn) — and with key staff positions held by graduate engineers, physicists and mathematicians, many with advanced degrees.

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Holder of many "firsts," such as
— first airplane to carry a pay load equivalent to its own weight. (1920)
— first globe-circling airplane. (1924)

Builder of the famous "DC" series of commercial aircraft.
— every six seconds of each day, a Douglas commercial airplane takes off or lands somewhere in the world.
— currently producing the ocean-spanning DC-7C.
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Currently building even finer transports, jet fighters and bombers.
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REFERENCES:
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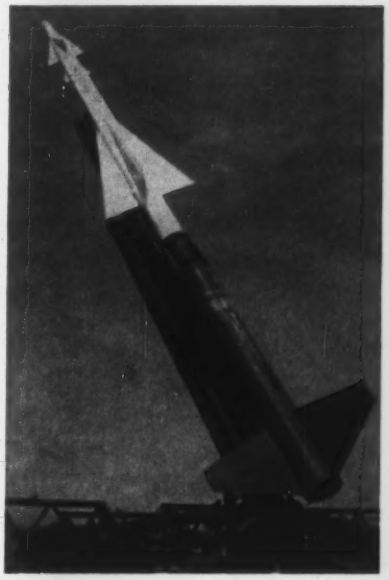

NIKE I, a radar-guided missile, intercepts bombers at supersonic speeds despite evasive action.

Engineers modify DC-8 configuration in wind tunnel tests for stability and control data.

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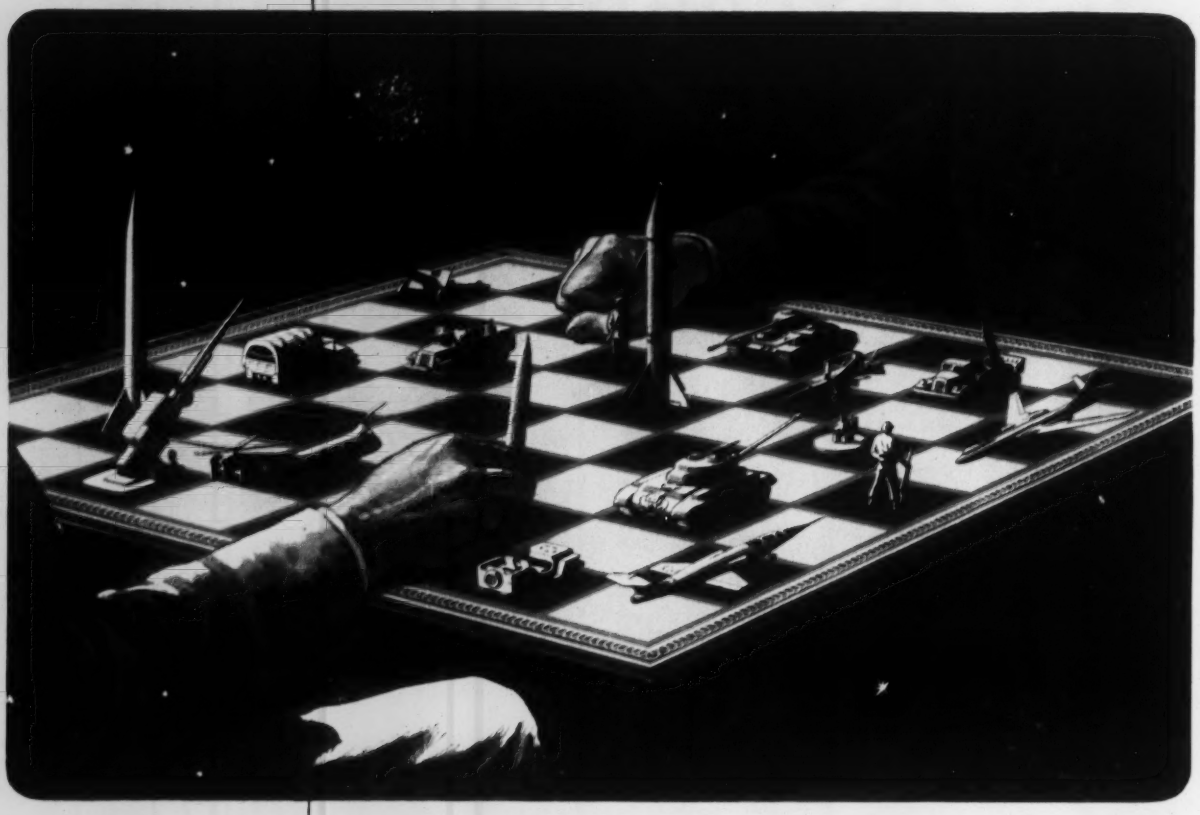

Tactics for Defense

The complexity of modern weapon systems, the variety in new development possibilities, the shortage of trained personnel and the limited time factor make it imperative for the United States Army to evaluate its present and future tactical capabilities. To that end, a new operations research group is being organized at JPL to explore present and future possibilities and to contribute to the understanding and solution of apparent problems.

Studies will be made regarding the offensive and defensive weapons now at our disposal as well as those being developed and proposed. Tactics for their current and probable use and disposition will be studied and evaluated. Information regarding known and probable opponent weapons and tactics must also be gathered and co-ordinated and a reasonable estimate made as to their possible employment. Plans and procedures for countering and offsetting such opponent activities are of immediate importance.

For the staff of this special group, the Jet Propulsion Laboratory seeks open-minded and imaginative engineers and scientists of every classification. If you are interested in and have a strong desire to become a part of such a program, you are invited to submit your resume for immediate consideration.

The Jet Propulsion Laboratory is a stable reseach and development center located north of Pasadena in the foothills of the San Gabriel mountains. Covering an 80 acre area and employing 1700 people, it is close to attractive residential areas.

The Laboratory is staffed by the California Institute of Technology and develops its many projects in basic research under contract with the U.S. Government.

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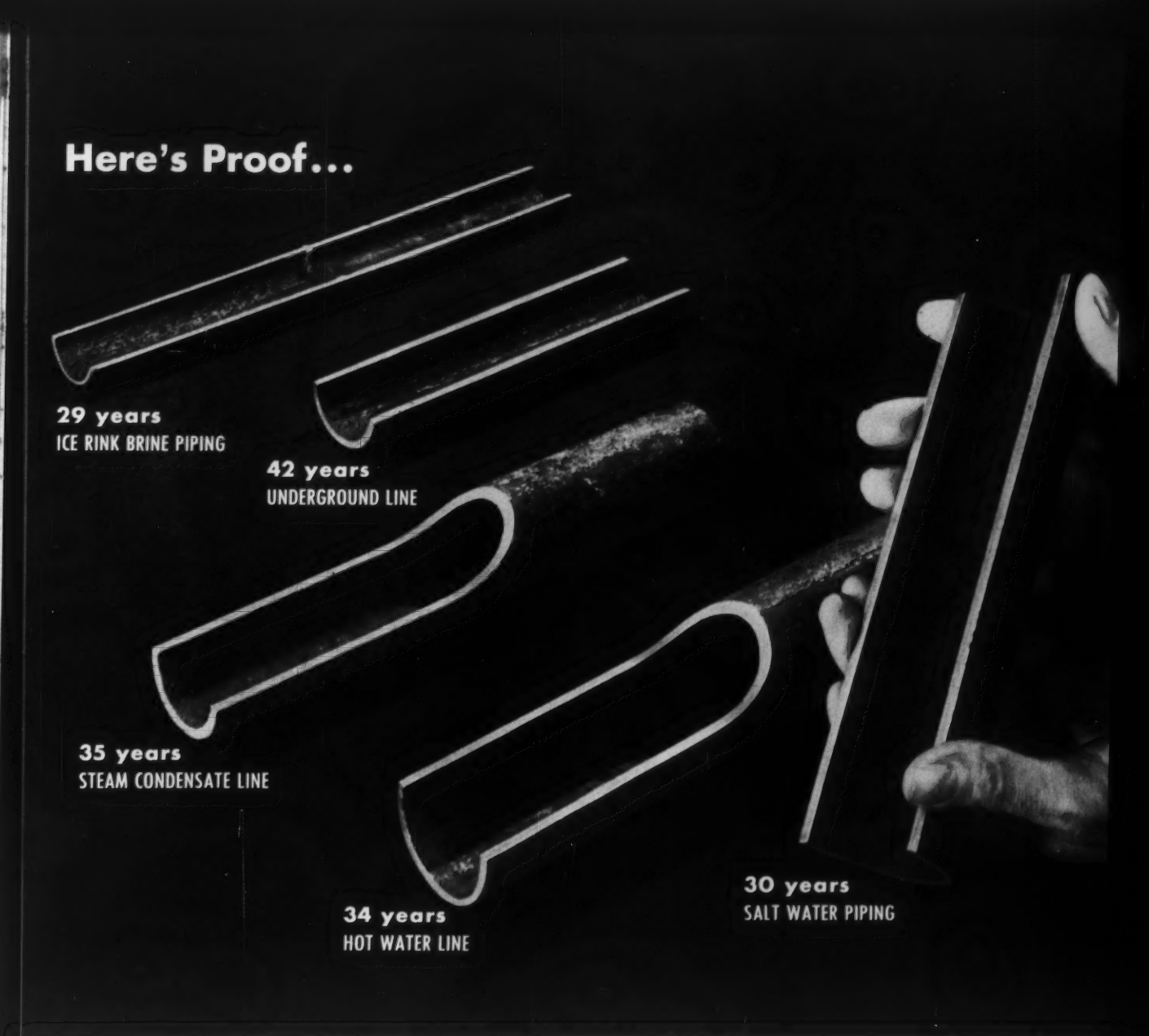

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Wrought Iron Pipe pays off in years of service rendered

There's a practical, dependable way to evaluate a piping material's potential in corrosive service: check its performance under actual field conditions.

The photo above shows how wrought iron pipe measures up when this service-life yardstick is applied. Here you see actual samples taken from wrought iron pipe installations in a variety of corrosive services. Some of these sections came from buildings that were being torn down. Some were cut from in-use installations by our laboratory staff.

The reasons why wrought iron pipe has lasted so long and remained in such excellent condition are found in the material's structure and composition. Tiny fibers of glasslike iron silicate are threaded throughout the body of high-purity iron. These non-rusting fibers are highly resistant to corrosive attack. When corrosion strikes, these fibers halt and detour the attack, prevent rapid pitting and penetration.

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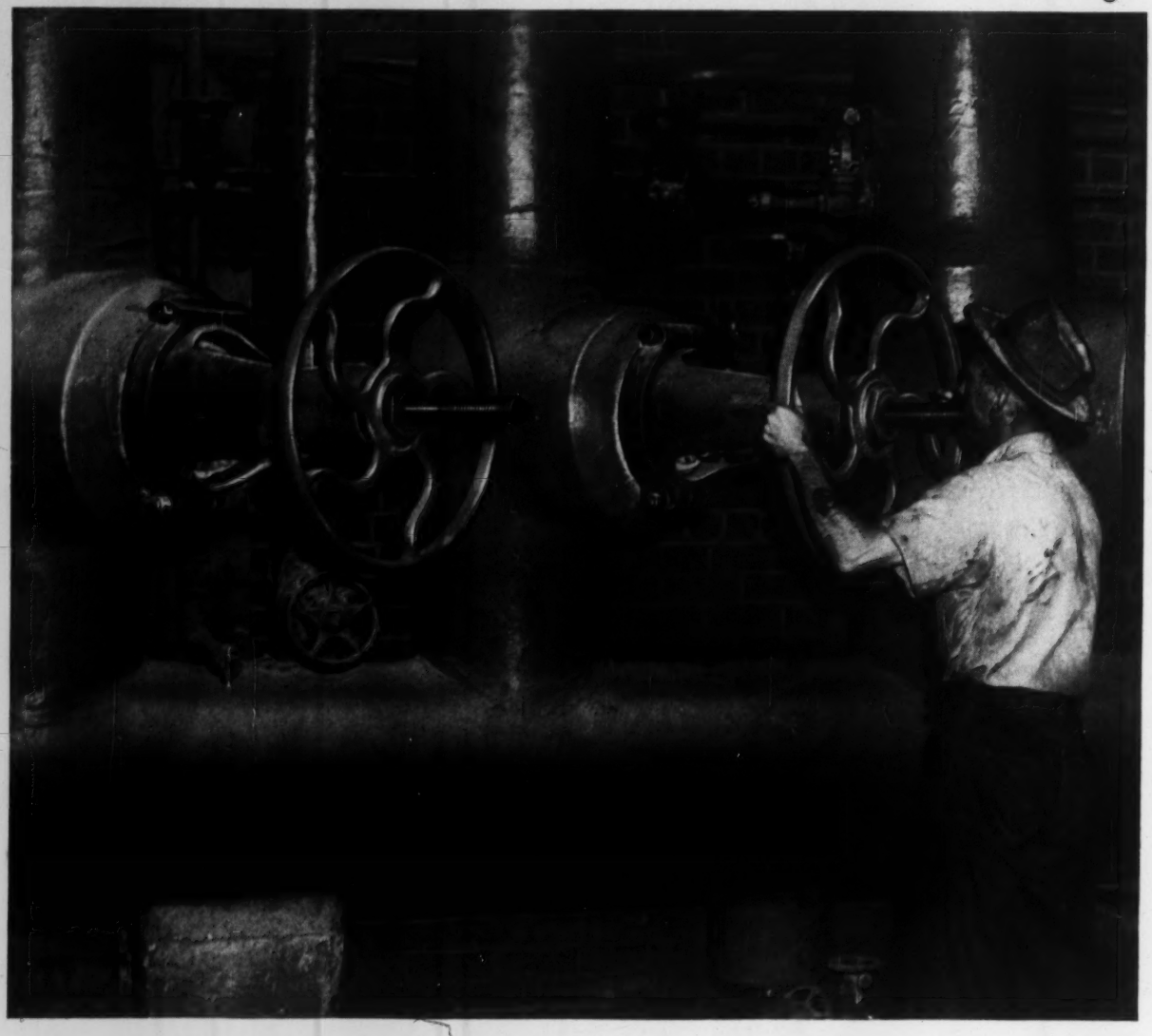

These valves helped the maintenance crew win a losing battle

This process industry plant saw the danger signal. Servicing leaky valve bonnet joints was taking too much time. Other important maintenance work was being neglected.

That's why, in 1947, when expanding the power plant, Crane Pressure-Seal Bonnet Gates were chosen for main steam service as shown above. Working pressure: 600 psi at 725 deg. F.

These Crane valves need no bonnet joint maintenance. The joint is leakproof—sealed tight by internal fluid pressure. Crane alloy seats and flexible wedge disc make closure tight and easy.

To date, the Crane Pressure-Seal Gates have given this plant over 9 years' uninterrupted service. The maintenance crew hasn't touched them except for routine care.

Full information on these modern power service valves is given in Circular AD-1936. Get a copy from your Crane Representative or by writing to address below.

Ask for Circular AD-1936

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Another cost-saving application of Amplex Powder Metallurgy

How to make a self-propelled rotary mower more compact and still permit the rotary blade to operate while the mower idled—*without increasing costs!* That was the problem company engineers tackled. One way was to combine three components—over-running clutch, oil pump piston cam, differential—into one. They experimented widely with designs and materials. Result: an OILITE powdered bronze worm gear with one side of the hub a cam operating the oil pump, the other side a wheel drive ratchet. (The other half of the ratchet—fixed to the drive shaft— OILITE powdered iron.) The design achieved the desired compactness and idling characteristics. OILITE powder metallurgy achieved a *major reduction* in cost, an *increase* in serviceability.

Do you have a design problem? Maybe Amplex has the answer. Write for detailed information about Amplex powder metal components—OILITE Bearings, Parts, Filters. Or call your nearest engineering representative listed in the yellow pages under "Bearings—OILITE."

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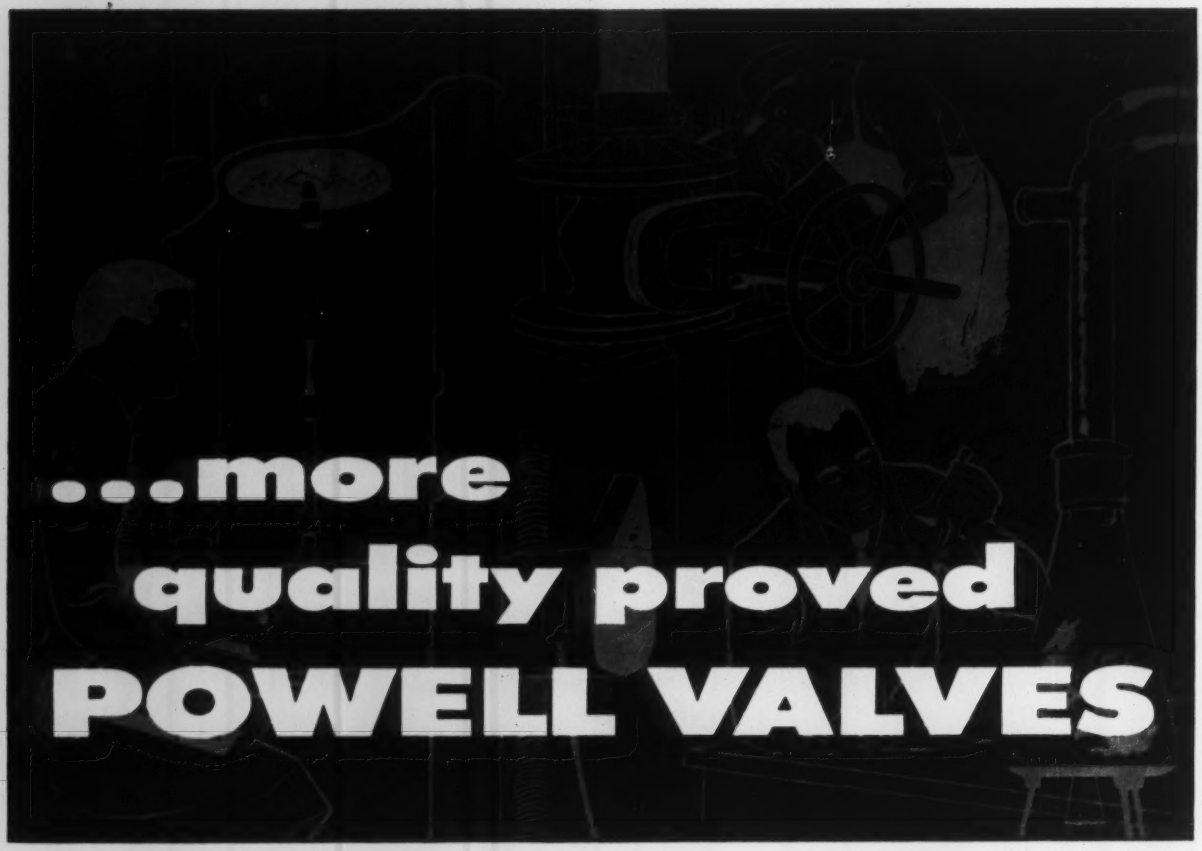


...more quality proved POWELL VALVES

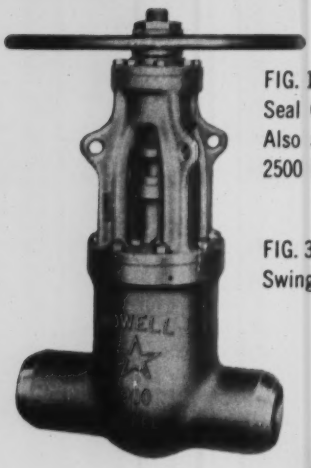


FIG. 19003 W.E.—Steel Pressure Seal Gate Valve for 900 Pounds. Also available for 600, 1500 and 2500 Pounds.

FIG. 3061 W.E.—300-Pound Steel Swing Check Valve.

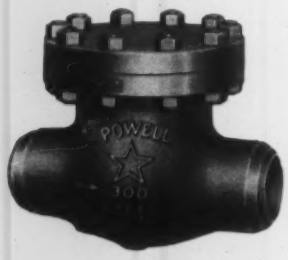
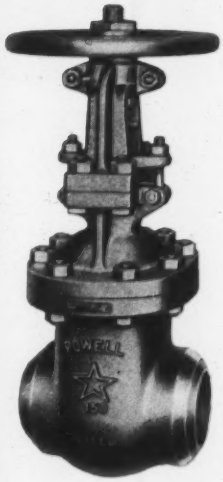


FIG. 1503 W.E.—150-Pound Steel O.S. & Y. Gate Valve.

FIG. 11365 W.E.—Steel Pressure Seal Horizontal Lift Valve for 1500 Pounds. 900-Pound Valves also available.



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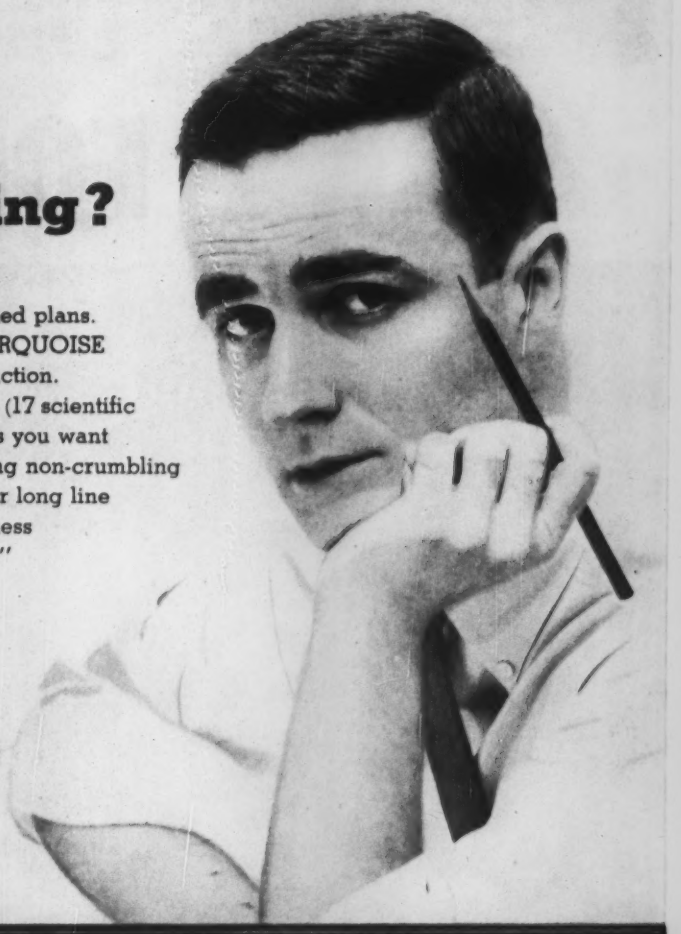

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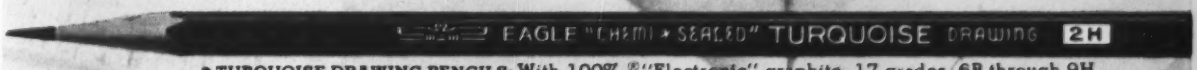

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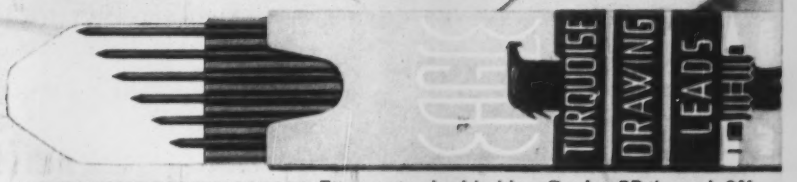

• **TURQUOISE DRAWING LEADS:** Fit any standard holder. Grades 5B through 9H.

• **TURQUOISE LEAD HOLDERS:** Hold any grade of Turquoise lead—so firmly that lead cannot be pressed back.

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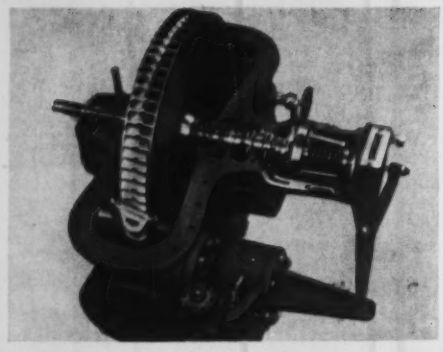
TURBINE BLADES CAN'T FOUL!

The Terry solid-wheel turbine is of the impulse, helical flow type. The steam issues from an expanding nozzle at high velocity and enters the wheel bucket where its direction is reversed 180°. As this single reversal uses but a portion of the available energy, the steam is returned to the wheel several times until practically all of the energy has been utilized. This principle makes possible the efficient use of steam in a single-piece, almost indestructible wheel.



Terry solid-wheel design permits large clearances

In the Terry solid-wheel turbine, the steam enters the buckets in a direction at right angles to the shaft, as shown above. This design eliminates the need for close clearances and provides positive blade protection.

The blades cannot foul. There is a one inch clearance on either side of the wheel. In addition, projecting rims on each side of the buckets prevent damage to the blades even though external thrust should move the wheel.

This is only one of the many advantages of Terry solid-wheel turbines. Write for complete details. Ask for a copy of bulletin S-116.

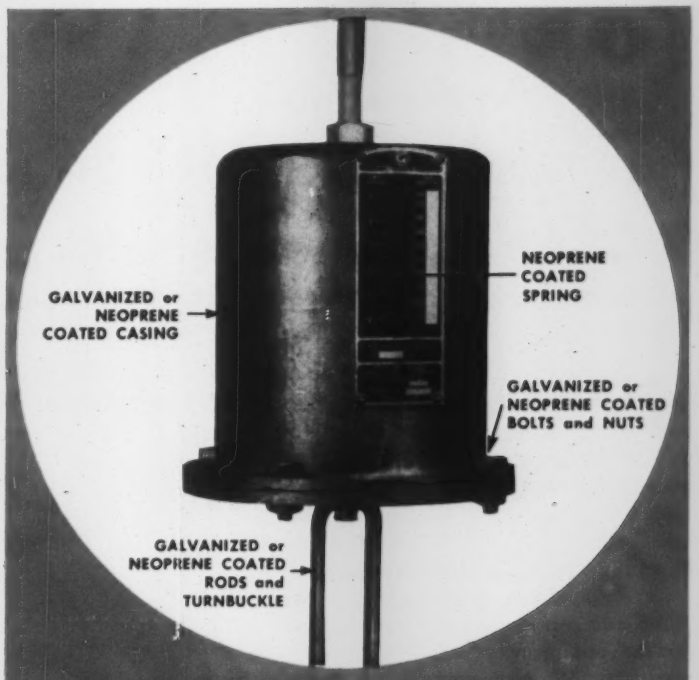
TERRY

TT-1206

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

NEW

weather-resistant, corrosion-resistant GRINNELL VARIABLE SPRING HANGERS...


GALVANIZED or NEOPRENE COATED CASING
NEOPRENE COATED SPRING
GALVANIZED or NEOPRENE COATED BOLTS and NUTS
GALVANIZED or NEOPRENE COATED RODS and TURNBUCKLE

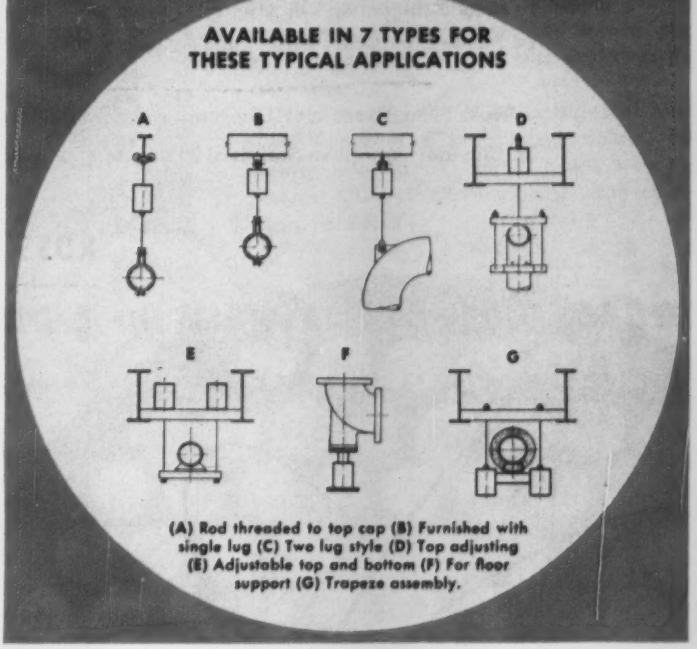
Another Grinnell First!

Grinnell pre-engineered spring hangers are now offered in two new lines to meet the need for spring hangers in installations subject to highly corrosive industrial conditions and to severe weather exposure.

These hangers are the result of extensive experimentation with various coatings for Grinnell's standard pre-engineered spring hangers. In addition to providing flexibility in pipe suspension, they provide versatility of application through their corrosion-resistant characteristics. They are . . .

1. Neoprene coated — for highly corrosive conditions such as those found in chemical plants and refineries. *All* parts of the hanger are neoprene coated to protect the base metal from a wide range of corrosives. The flex life of the spring is unaffected by the neoprene . . . the coating resists cracking or flaking over a wide temperature range.

2. Galvanized — for outdoor installations where weather conditions are severe. All parts of the hanger are galvanized except the spring, which is neoprene coated to avoid alteration of temper, hydrogen embrittlement and decreased flex-life of the spring — usual hazards to springs from the galvanizing process.


AVAILABLE IN 7 TYPES FOR THESE TYPICAL APPLICATIONS
A
B
C
D
E
F
G
(A) Rod threaded to top cap (B) Furnished with single lug (C) Two lug style (D) Top adjusting (E) Adjustable top and bottom (F) For floor support (G) Trapeze assembly.

Along with the obvious advantages of such corrosion and weather-resistant characteristics, consider these features . . .

- Maximum variation in supporting force per ½" of deflection is 10½% of rated capacity — in all sizes.
- Precompression* assures operation of spring within its proper working range, as well as saving valuable erection time. Reduced over-all height saves space.
- 18 sizes available from stock for load ranges from 53 lbs. to 12,000 lbs.
- Available in 3 spring lengths for travel ranges of 1¼, 2½, and 5 inches.
- Installation is simplified by integral load scale and travel indicators.

**Precompression is a patented feature.*

GRINNELL

AMERICA'S #1 SUPPLIER OF PIPE HANGERS AND SUPPORTS

Grinnell Company, Inc., Providence, Rhode Island • Coast-to-Coast Network of Branch Warehouses and Distributors

pipe and tube fittings • welding fittings • engineered pipe hangers and supports • Thermolier unit heaters • valves
Grinnell-Saunders diaphragm valves • pipe • prefabricated piping • plumbing and heating specialties • water works supplies
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On this subject:

HEAT EXCHANGERS FOR NUCLEAR SYSTEMS

. . . Ross speaks with experience

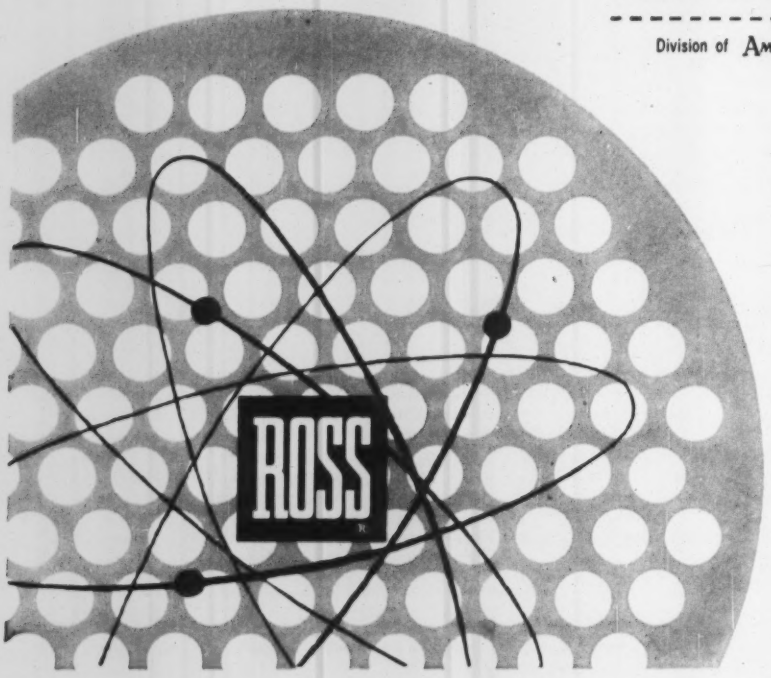
The initiative which Ross has taken in virtually every field of heat exchanger development applies to the nuclear energy field, as well. Ross engineers were early at work.

Starting with exchangers designed and fabricated for the Manhattan Project, and carrying on down right through to today, Ross has been steadily building its reputation in nucleonics' circles.

The readiness of Ross to perform engineering development; the possession of the necessary skills to work with specialized materials; the ability accumulated through experience to meet stringent specifications . . . these and others are points which Ross engineers would be pleased to discuss with you. Yes, Ross can speak with experience. Your inquiries are invited.

Ross Heat Exchanger Division of American-Standard, Buffalo 5, N. Y.
In Canada: American-Standard Products (Canada) Limited, Toronto 5, Ont.

ROSS HEAT EXCHANGER
Division of AMERICAN - Standard



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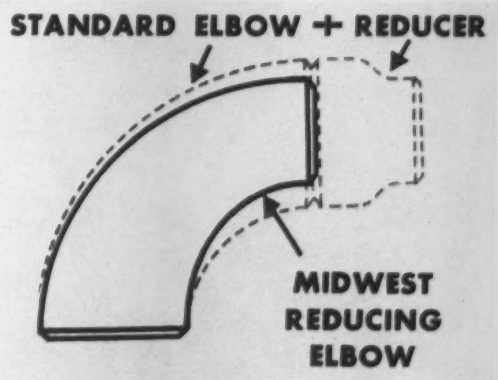
Your demand for Midwest Reducing Elbows has dictated our decision to make them STOCK items in all pipe sizes to 30″ OD and all reductions to one-half the nominal pipe size. We now have a modest stock of practically all sizes in standard and extra heavy weight, and this stock is being added to as rapidly as possible.

Midwest Reducing Elbows are also made as "specials" in heavy wall and/or any weldable alloy. The fact that our raw material is plate instead of tubing greatly increases our range of wall thicknesses and types of materials . . . it also improves the delivery.

Note the significant advantages of Midwest Reducing Elbows listed below. For further information, get in touch with the nearest Midwest Distributor or write us for Catalog 54.

✓ CHECK THESE ADVANTAGES OF MIDWEST REDUCING ELBOWS

- ✓ Save more than ⅓ of the welding required by standard elbows and reducers.
- ✓ Reduce turbulance and pressure drop because of gradual taper.
- ✓ Fit into smaller space than straight elbows and reducers.
- ✓ Greater piping design opportunities . . . easily adaptable for making special reducing fittings such as "bull-head" tees and back-outlet elbows.
- ✓ Improve appearance of piping.
- ✓ Available from stock in sizes to 30″ OD. (Heavy walls and alloys on special order.)



MIDWEST PIPING COMPANY, INC.

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PLANTS: ST. LOUIS, CLIFTON, N. J. and LOS ANGELES

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ONE OF A SERIES

go where engineers are free to do creative work

One of the things that irks engineers most, surveys show, is getting burdened with dull, routine chores. This takes the fun out of engineering, and slows you down.

You'll be ahead, therefore, if you select a company that helps you avoid this kind of career impediment.

Take Boeing, for instance. Boeing frees engineers for creative assignments by hiring engineering aides and draftsmen to handle routine jobs. Boeing engineers concentrate on *engineering*.

Another point: you'll find excitement aplenty at Boeing, working with men who are literally writing the book in the field of long-range jet-powered aircraft. You'll work on such projects as advanced civil and military jet airplanes, the supersonic BOMARC guided missile weapon system, and top-secret research programs.

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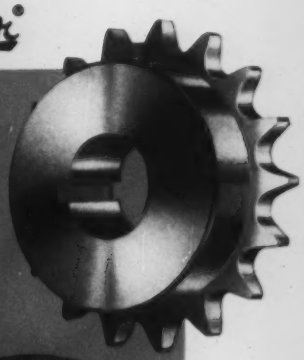
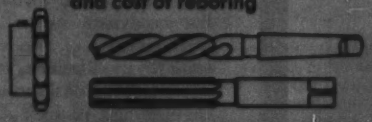
Here's how YOU SAVE with BOSTON Gear

BORED-TO-SIZE SPROCKETS

complete with keyway and set screw... ready to install



YOU SAVE time and cost of reboring



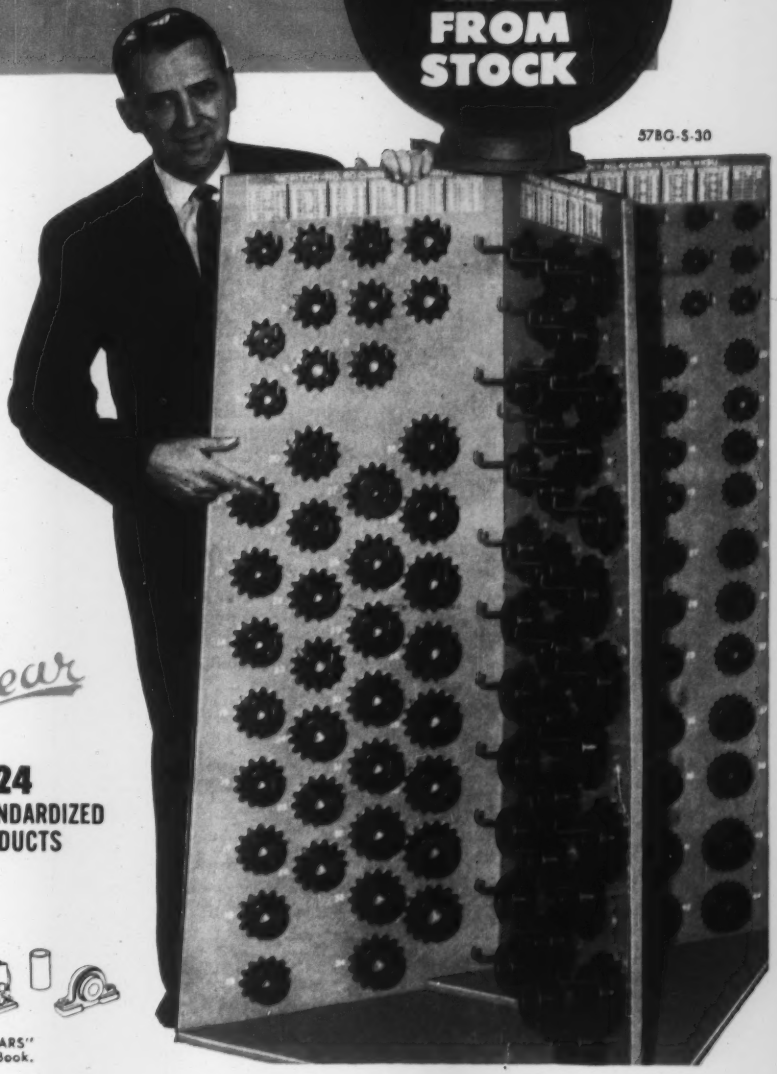
YOU SAVE time and cost of keyway cutting

YOU SAVE time and cost of drilling and tapping for set screw

YOU SAVE delay and cost of downtime in emergencies

76 PINION SIZES WITH **321** BORE SIZES **FROM STOCK**

57BG-S-30



Your Boston Gear Distributor can deliver promptly any size and bore you need from the full selection of 321 different pinions on his BORED-TO-SIZE SPROCKET stock rack.

Why "do-it-yourself" . . . at double the cost? Select the sprocket you need FROM STOCK, and get Boston Gear precision, finish, and performance that assures longer service life for both sprocket and chain. See Catalog No. 56 for complete listings — and other Boston Gear Sprockets to meet any drive need. Boston Gear Works, 66 Hayward St., Quincy 71, Mass.

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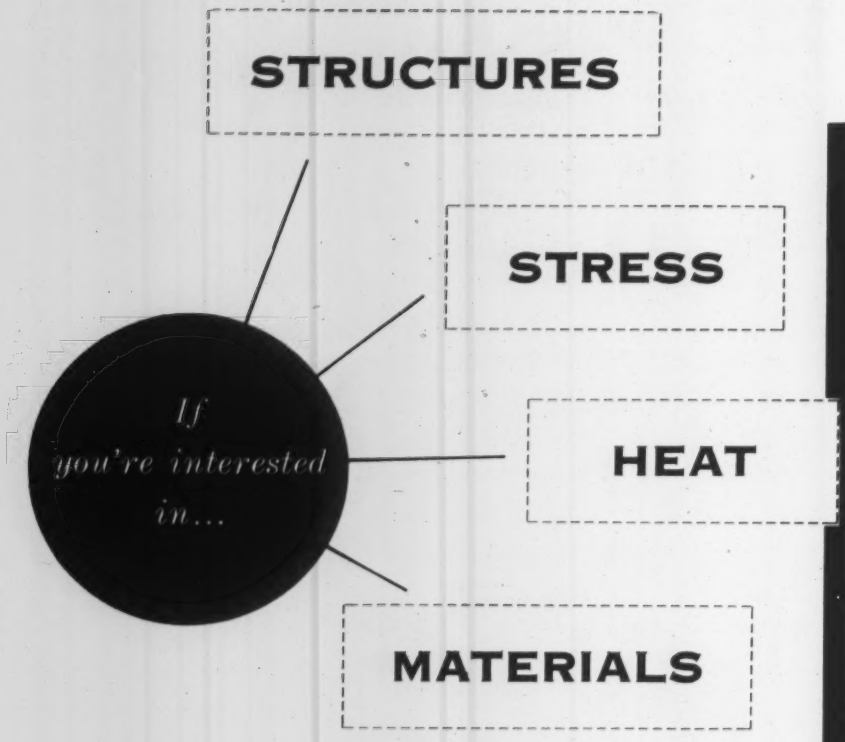
For nearest Distributor, look under "GEARS" in the Yellow Pages of your Telephone Book.



there's an exceptional opportunity for you at Hughes.

There are many excellent openings for mechanical and aeronautical engineers for challenging assignments in the areas of high-speed missiles, aircraft structures, and antennas. This work concerns developing practical solutions to both theoretical and actual problems of heat transfer, structural analysis and design, stress analysis, materials section, and instrumentation.

The projects at Hughes have both military and commercial potential. Men qualified for these activities are assured of a practically unlimited future in a career with the West's leading center for advanced electronics.

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HUGHES

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A few of our openings include:

AERONAUTICAL ENGINEER
For aerodynamics consultation. Determination of aerodynamic loads for modifications to aircraft. Additional aeronautical engineering tasks such as stress, mechanical engineering, hydraulics, etc.

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To design and develop electro-mechanical servos and rate measuring systems for application in airborne instrumentation systems.

MECHANICAL ENGINEER
To handle the design of mechanical components related to laboratory work in the field of microwaves.

MECHANICAL ENGINEERS
To participate in the design and development of missiles, missile launchers, aircraft structure, component installation, environmental test equipment, hydraulic and general mechanical design.

AERONAUTICAL ENGINEERS
For the analysis and design of missile launching equipment for high-speed aircraft, including coordination and liaison with many major airframe manufacturers.

DYNAMICS ENGINEERS
To work on shock and vibration problems in an aerothermal environment. Also elasticians to work on advanced aerothermo-elastic problems associated with high-speed flight.

ENGINEER
For research related to the selection of materials and development of fabrication techniques.

These positions also available in the Research and Development activity at Tucson, Arizona.

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in its unique combination of properties

No other design material can match Stainless Steel in its combination of desirable properties: corrosion resistance, strength, hardness, beauty, cleanability and easy fabrication. For a reliable source of supply, United States Steel offers you the widest range of types, finishes and sizes.

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UNITED STATES STEEL

For Sanitation

Food juices are incredibly corrosive, so some restaurants have a lot of trouble in their cold storage rooms because the racks corrode and harbor bacteria. Eastern Steel Rack Company makes racks from Stainless Steel. They are easy to keep clean; and, for all practical purposes, they *never* wear out.

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This petrochemical extract fractionator was originally made from carbon steel . . . but corrosion ate through the plates and put it out of service in *just two months*. They lined the tower with type 316 Stainless Steel. When examined, the tower had been in service 21 months, and the Stainless was still in good condition.

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Hawthorne Paper Company, Kalamazoo, Mich., goes to extraordinary lengths to guard against color contamination. Old wooden tanks were thrown out and replaced with Stainless Steel. According to the men at Hawthorne, the Stainless has absolutely no contaminating effect, and it's easy to fabricate.

attention...

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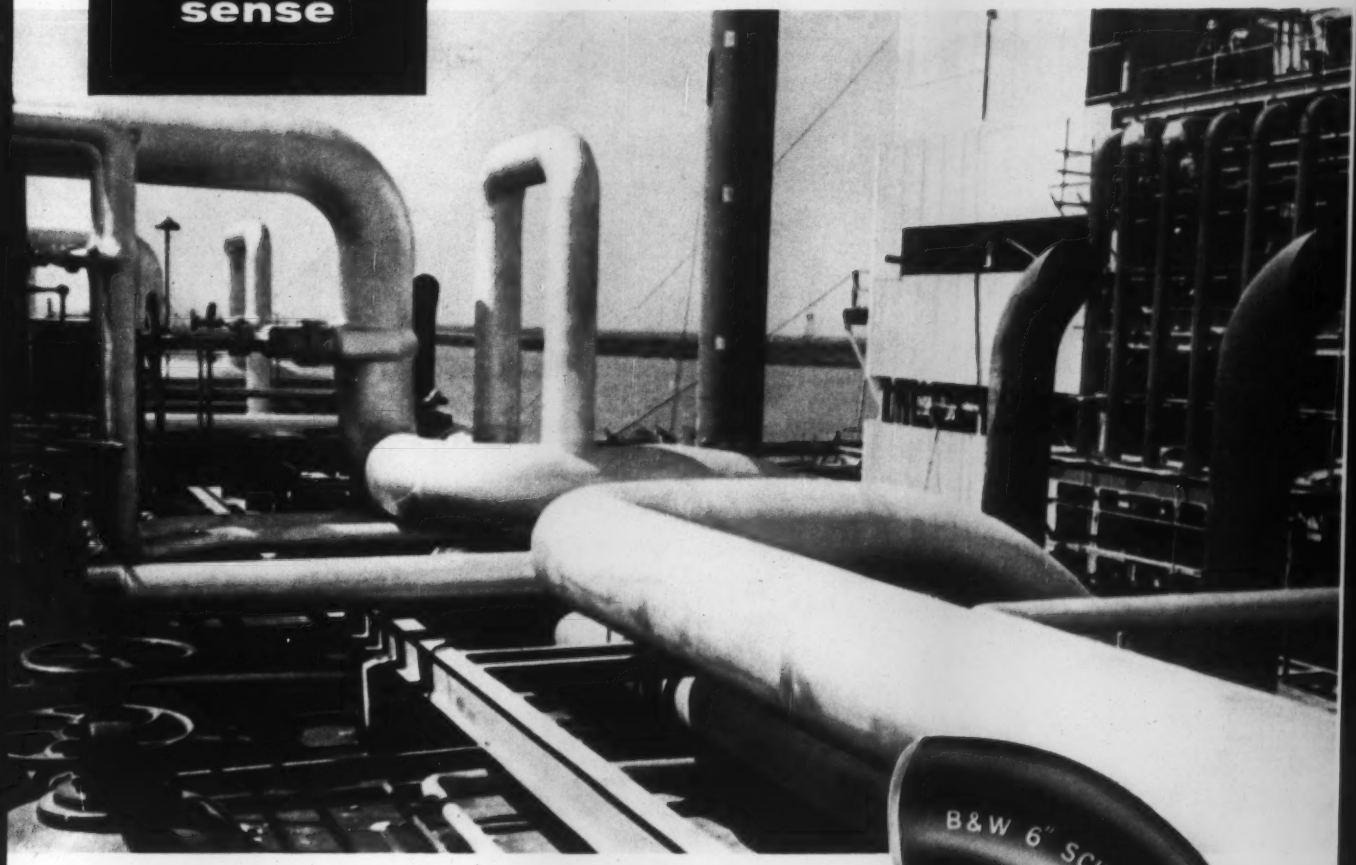
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

result of an engineer's good common sense

insulation is easier and faster to apply when seamless welding fittings are used



THANKS to the engineer who specified B&W Seamless Welding Fittings, no humps or bumps had to be insulated here. Welding fittings became an actual part of this smooth, streamlined piping. And with a sound weld, welded connections are leakproof, pipelines are permanent. Insulation never has to be restored because of leaky joints. Therefore, maintenance is practically non-existent.

Seamless Welding Fittings combine strength with lightness-in-weight and allow closer nesting. B&W's dimensional accuracy such as full radius, true circularity and smooth walls of uniform thickness permits uninterrupted flow even under highest temperatures and pressures.

Be sure — and specify B&W Seamless Welding Fittings and Forged Steel Flanges. They're available in a complete range of sizes and types in carbon steel and the B&W CROLOYS.

THE *NATURAL* SOURCE FOR ALLOY FITTINGS

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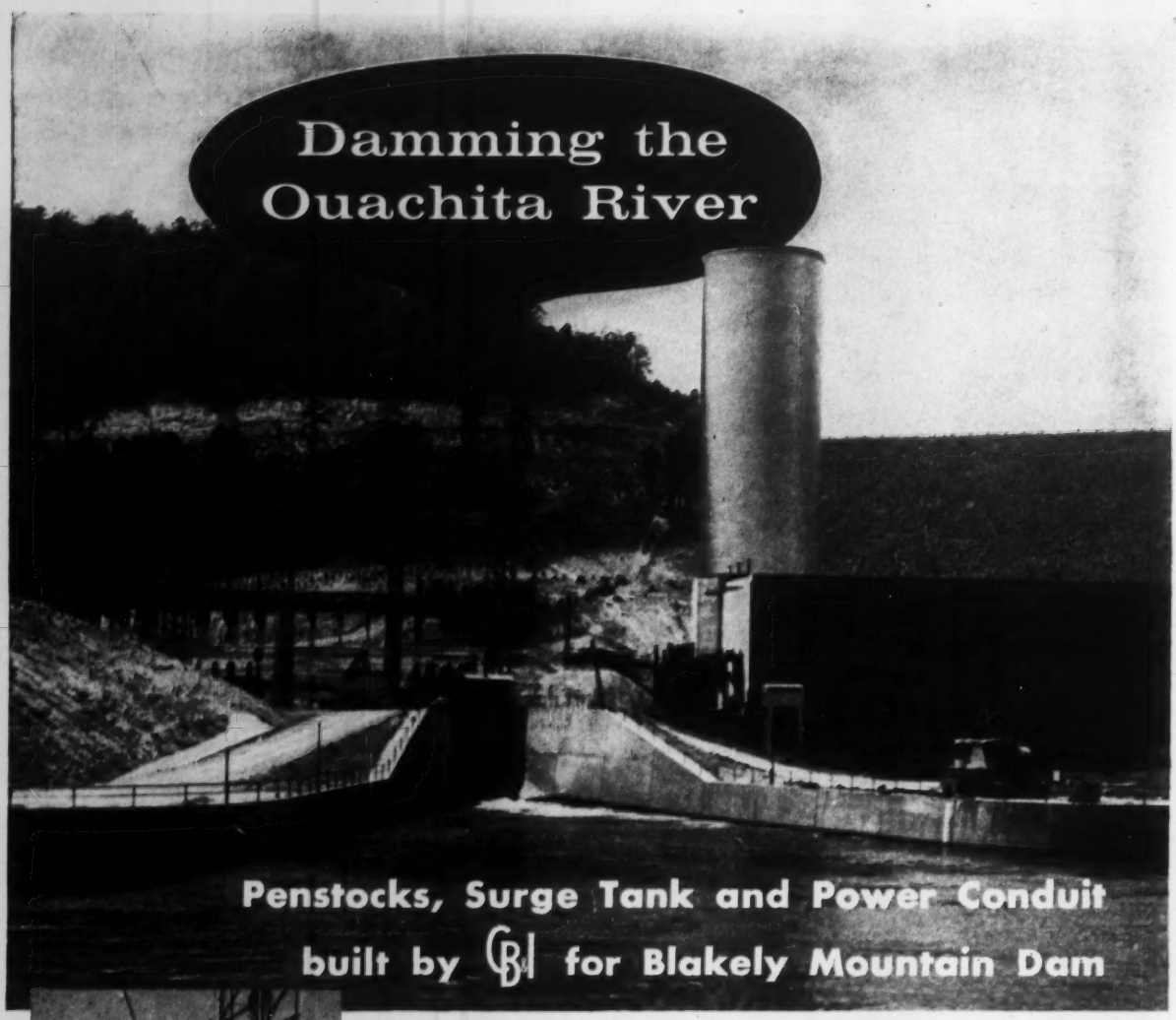
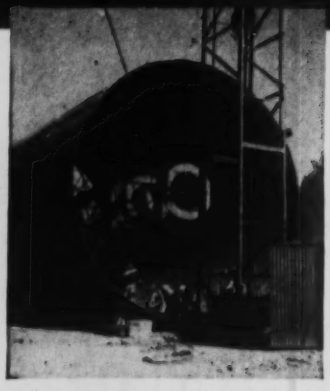
Seamless welding fittings and forged steel flanges, seamless and welded tubular products — in carbon, alloy and stainless steels.

Damming the Ouachita River



Penstocks, Surge Tank and Power Conduit built by CB&I for Blakely Mountain Dam



Section of one of the penstocks fabricated and assembled by CB&I at Blakely Mountain Dam near Hot Springs, Arkansas.

CB&I fabricated and erected 17-ft. and 16-ft. diam. penstocks, a 55-ft. diam. by 149-ft. high surge tank and a 24-ft. diam. power conduit for Al Johnson Construction Company, Minneapolis, Minn., at the Blakely Mountain Dam, Arkansas. The dam, built for the Corps of Engineers, U. S. Army on the Ouachita River near Hot Springs, is a project of the Vicksburg District Corps of Engineers.

CB&I has four strategically located plants with complete facilities to build steel plate structures for hydroelectric generating plants and water diversion projects. Our vast *experience* and our *craftsmen* enable us to design, fabricate and erect structures to your most rigid specifications.

Write our nearest office for further information.

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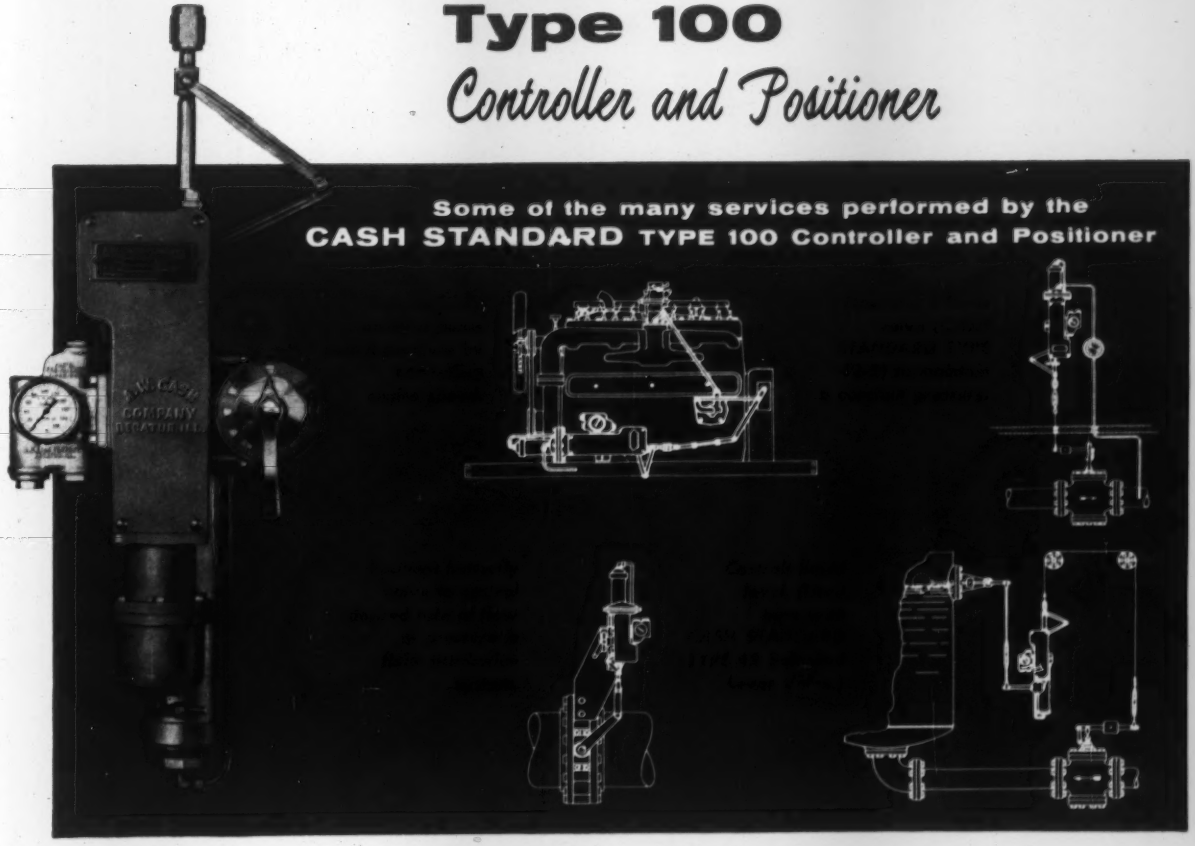
automatic control or positioning problem?

Here's the answer . . . the versatile

CASH STANDARD

Type 100

Controller and Positioner



include this unit in your process system as:

1. A controller with self-contained positioning mechanism.
2. A power positioner actuated by a signal from another controller.

The Type 100 coupled with various types of final control elements will accurately control:
• Pressure • Liquid level • Rate of flow • Other process variables

The Type 100 features: • Feed back type control • Adjustable range • High sensitivity • Linear or curved line characteristics • Reverse or direct action • Optional manual control • Double acting cylinders, 6″ or 12″ stroke, 2″, 2¾″ or 4″ bore for operating pressures up to 125 psi. (Also suitable for larger cylinders in combination with volume booster when higher thrusts are desired.) • Operation by air, oil or clean water.

Available for these signal ranges: • Vacuum • Differential pressure • Pressures up to 600 psig. • Lever motion

WRITE TODAY for complete information, including literature, on this versatile instrument. Dept. C

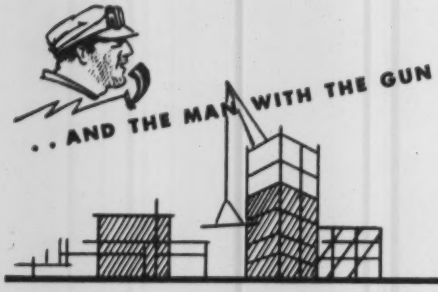
CASH STANDARD

A. W. CASH COMPANY, P. O. Box 551, Decatur, Illinois

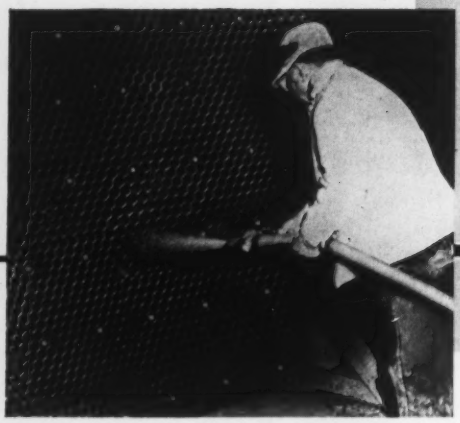
Pressure, Hydraulic, Temperature, Process and Combustion Controls

ELECTRONICS and *Mud*

Notice the ear phones on his head. He is in constant voice communication with the gunnite operator—receives instructions so that exactly the right proportions of water and dry castable are used. Result: longer refractory life in refinery vessel installations.



As he "guns" the castable-water mixture onto the retaining mesh, the operator talks to the man governing the mix—telling him when the mixture is coming in too wet or too dry. Prior to walky-talky communication, hand signals were given from hundreds of feet away.



Off-stream time hinges upon the durability of the equipment in the refinery. That's why Bigelow-Liptak has concentrated so much upon improvement of castable application to refinery vessels. As a result, you'll find B-L installations are hanging up record after record for long life and consequently helping to reduce the per-barrel cost of refined products. Remember that Bigelow supplies a complete one-source service to refineries: engineering, materials and erection. Better investigate today!

BIGELOW-LIPTAK *Corporation*

AND BIGELOW-LIPTAK EXPORT CORPORATION

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UNIT-SUSPENDED WALLS AND ARCHES

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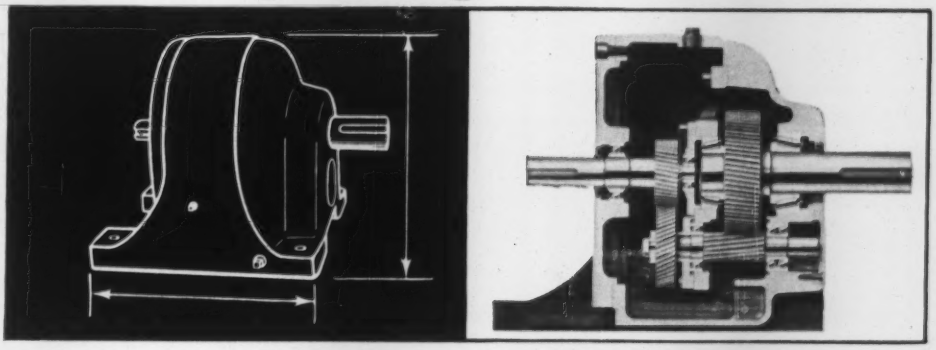
NEW compactness outside...
NEW simplicity inside...



MINIMIZED SPACE REQUIREMENTS and easier layouts result from location of input and output shafts in same horizontal and vertical planes.

ONE LOW-SPEED GEAR SET per drive size and maximum accessibility of all operating parts simplify servicing and ratio changes.

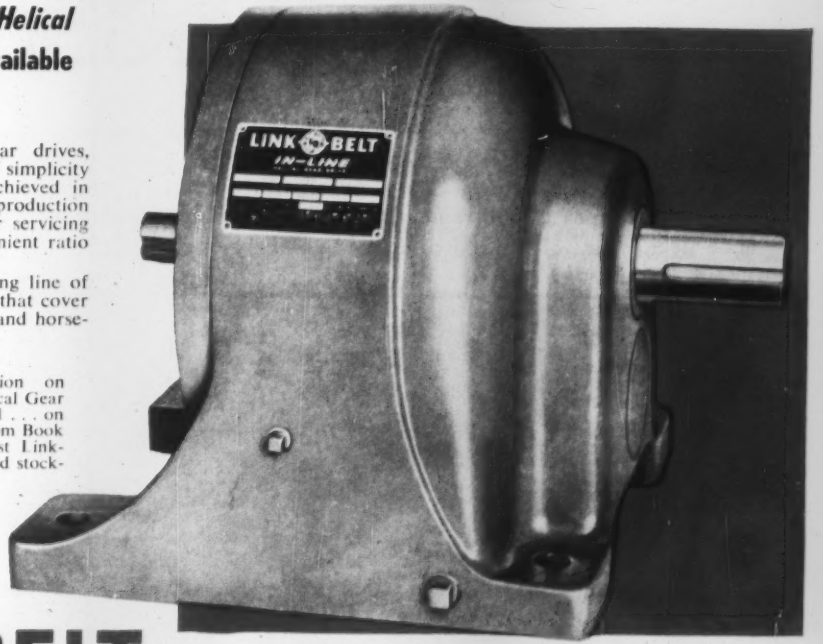
...and built for smoother speed reduction *all the way around*

NOW! *LINK-BELT In-Line Helical Gear Drives* immediately available from stocks near you

With these new in-line helical gear drives, Link-Belt offers you a high degree of simplicity and standardization never before achieved in speed reducers. In terms of your production efficiency, it means less and simpler servicing . . . maximum life . . . quick, convenient ratio changes.

Link-Belt also makes an outstanding line of heavy-duty parallel shaft gear drives that cover a wider ratio range up to 300 to 1 and horsepowers to 2000.

Get full information on Link-Belt In-Line Helical Gear Drives from Book 2651 . . . on parallel shaft drives from Book 2619. Ask your nearest Link-Belt office or authorized stock-carrying distributor.



Available with double or triple gear reductions . . . ratios 6.2:1 to 292:1 . . . capacities to 118 hp. Conform dimensionally with new NEMA motor sizes.

LINK-BELT

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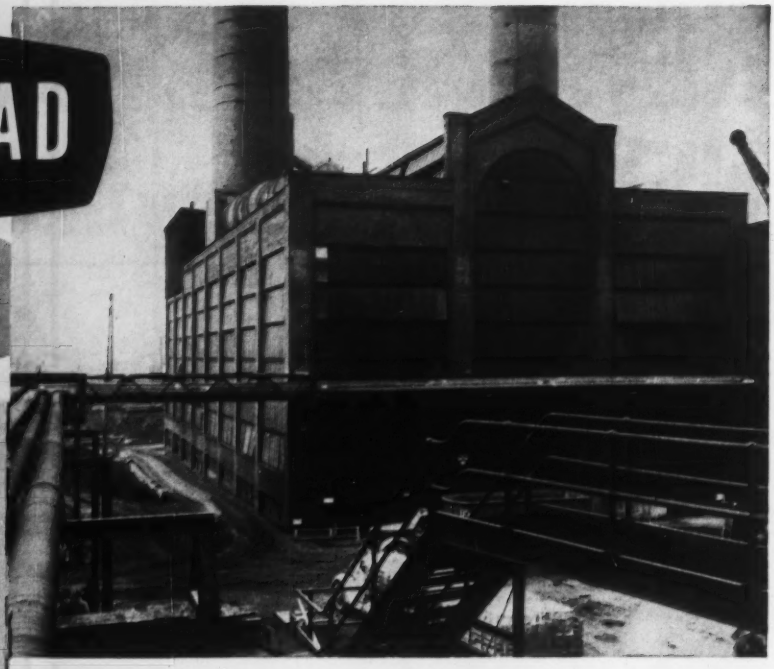
OVERHEAD

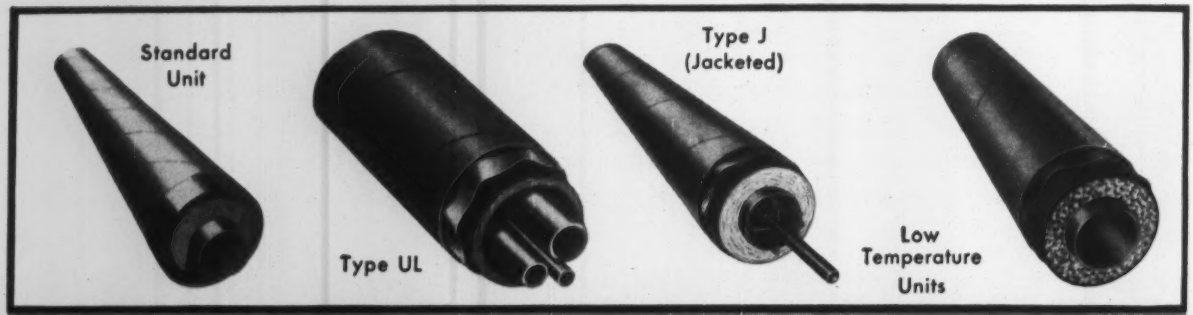
OR

underground



Ric-wiL offers the COMPLETE quality line of prefabricated piping systems

Ric-wiL factory prefabricated piping systems, *timed* to your schedule and *shipped* directly to the job site, can save you valuable time and money. Insulated units are available for steam, hot water, oil, other viscous fluids, process liquids and refrigeration lines . . . and remember . . . Ric-wiL is the quality system of exceptionally high mechanical strength and thermal efficiency.



Quality Piping Systems . . .
. . . of Exceptionally High Thermal Efficiency

RIC-WIL PREFABRICATED INSULATED PIPING SYSTEMS

BARBERTON, OHIO

IN CANADA: THE RIC-WIL COMPANY OF CANADA LIMITED

Write for a copy of the new Ric-wiL Catalog . . .

MAKING GASKET SELECTION EXACT

It's easy to select the right Flexitallic Spiral-Wound Gasket for known sealing requirements because —

(1) Gasket designs have been so developed that the bolt load for a given pressure series is balanced by the gasket reaction;

(2) Structural characteristics compensate for variations in operating conditions.

For 45 years, devoted exclusively to Spiral-Wound Gasket construction, Flexitallic Gaskets have been designed to meet specific conditions of pressure, temperature, thermal shock, chemical attack and cyclic operation. Spiral wound V-crimped plies of required metal with alternating plies of proper filler result in a gasket with compression characteristics like those of a pre-calibrated spring.

Flexitallic Gaskets—for all pressure/temperature ranges from vacuum to 10,000 lbs. from extreme sub-zero to 2000°F. For all standard joint assemblies. In four thicknesses: .125", .175", .250", .285".

FLEXITALLIC GASKET CO.
8th & Bailey Sts., Camden 2, N. J.
Representatives in principal cities

Flexitallic®
SPIRAL-WOUND GASKETS
FOR PIPE FLANGES, PRESSURE VESSELS AND PROCESS EQUIPMENT

*Flexitallic is a registered trade name. No one else can make a Flexitallic Gasket. Look for *Flexitallic Blue*—it's our exclusive blue-dyed Canadian asbestos filler.

If you're expecting to read another offer of career opportunities presented on a silver platter, together with a certified rosy future neatly packaged in Fate-proof plastic—stop right here.

On the other hand, if you realize that all the bright promises and special inducements in the world cannot alter the fact that hard work, ability, and the drive to apply them are the things that make and seize real opportunities—you'd do well to read on.

Don't get the idea, because of the foregoing, that we underrate ourselves in any way. Quite the contrary. We know that our work—design and development of nuclear weapons—is as important as any being done today. We know that our working conditions and employee benefits are second to none. We know that we provide real opportunities for growth and advancement—for qualified people who have what it takes. We know, too, that living conditions at our locations—in terms of climate, housing, schools, recreation, and cultural facilities—are hard to match anywhere. At the same time, we know that it's up to you to decide whether or not you agree with us. We also have the idea that it's up to you to convince us of your ability.

If you'd like to know more about us—our work, our background, and both our laboratories, one in Albuquerque and one near San Francisco, we'll be happy to send you our illustrated brochure that tells the whole story. Just write to Staff Employment Division 553.

SANDIA CORPORATION

ALBUQUERQUE, NEW MEXICO

What shape is a quality fastener?

Here is a handful of ELASTIC STOP® nuts. Each has ESNA's familiar red locking collar . . . is self-locking and vibration-proof. Each is a readily assembled, one-piece unit. Each provides positive protection against thread corrosion . . . prevents liquid seepage along bolts. Each is made from the finest of raw materials. Each is exactly controlled as to finished dimensions, class of thread fit and finish. Each is now in use on critical applications, with a record for uniform high quality that is unmatched.

Most of them are standard parts. Some originated as the result of a specific request for ESNA's help with an important fastening problem.

Isn't it logical to call on us with your next fastening problem?

ELASTIC STOP NUT CORPORATION OF AMERICA

ESNA TRADE MARK / ROLLPIN TRADEMARK

Dept. N62-311, Elastic Stop Nut Corporation of America
2330 Vauxhall Road, Union, New Jersey

Please send the following free fastening information:

☐ ELASTIC STOP nut bulletin ☐ Here is a drawing of our product. What self-locking fastener would you suggest?

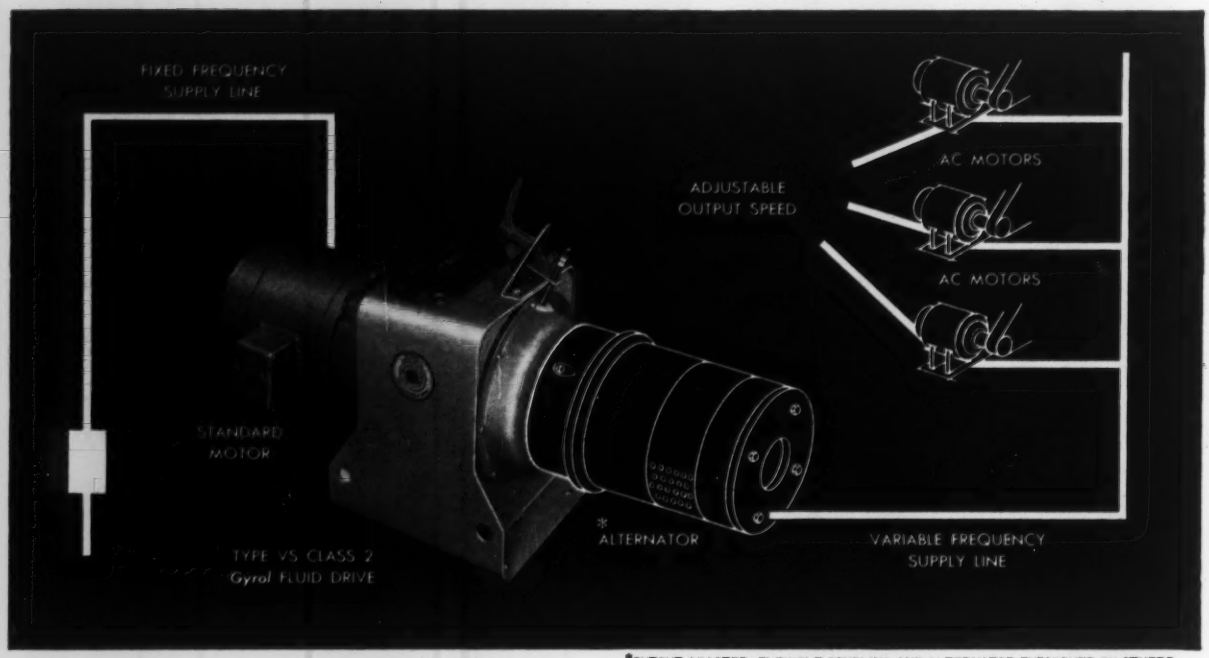
Name_____ Title_____

Firm_____

Street_____

City_____ Zone_____ State_____

Now—get matched, adjustable-speed control of AC squirrel-cage motors with American Blower *GÝROL*® Fluid Drives



*OUTPUT ADAPTER, FLEXIBLE COUPLING AND ALTERNATOR FURNISHED BY OTHERS.

A Gýrol Fluid Drive coupled to a standard alternator can vary the output speed of two or more AC motors. For example, a standard induction motor can operate at rated speed at 60 cycles, or half rated speed at 30 cycles, since speed for a given motor is proportional to frequency.

Here's a simple system for varying the output of two or more standard, constant-speed AC induction motors – simultaneously – to equalize load distribution, prevent costly machinery breakdowns.

An alternator, driven through an adjustable-speed Gýrol Fluid Drive, makes variable frequency available from a fixed-frequency power source. Since AC motors operate at speeds proportional to the frequency of applied power, motor speed is controlled by merely regulating the Gýrol Fluid Drive.

What's more, motors of different speeds or types can be used in the same system, and will change speeds proportionately; single-motor systems can also be set up. Control can be manual, semi-automatic, or automatic, and is adaptable to infrequent or frequent repeat cycling.

If you're looking for more dependable, lower cost adjustable-speed control of driven machinery, with fewer breakdowns, lower maintenance, why not look into a Gýrol Fluid Drive coupled to a standard alternator. Call our nearest branch office for full details. American Blower Division of American-Standard, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ont.

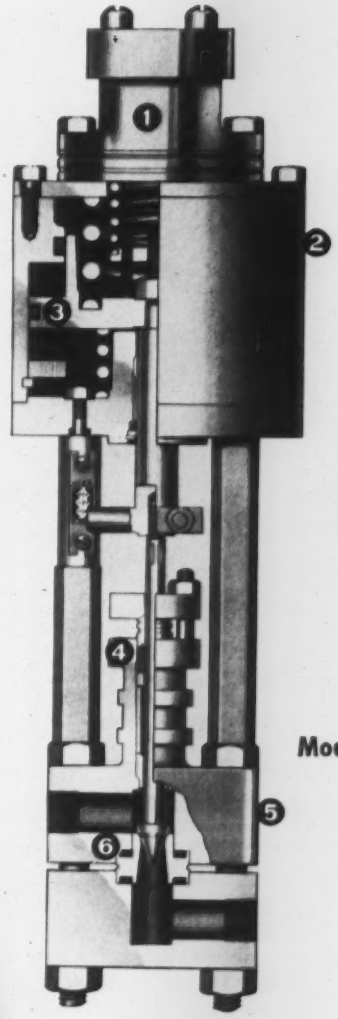
AMERICAN BLOWER

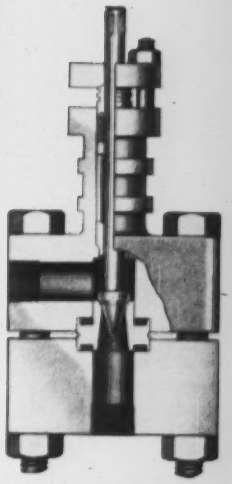
Division of AMERICAN-Standard

Split second action ...small flow control ...at 6,000 psi

New achievement by Annin in high pressure control and precise valve response for Research–Development–Process applications

Annin's new Model 9460, designed for working pressures to 6,000 psi, provides research, pilot plant and process control engineers with an extremely responsive small flow control valve suitable for low capacity systems. The operator will fully stroke in either direction in 0.75 seconds or less. New design features include: ❶ integral positioner, open-on-air-failure or close-on-air-failure action; ❷ Annin's 600 Series Domotor operator; ❸ differential area piston, eliminating need for loading regulator; ❹ universal stuffing box for −400°F to 750°F; ❺ offset globe or angle body design; ❻ valve plug stem and seat ring common to both globe and angle bodies. For reliable fluid control and flexibility of application Annin offers the *best source* for solving any small flow control problem.





Model 9461 *angle body*

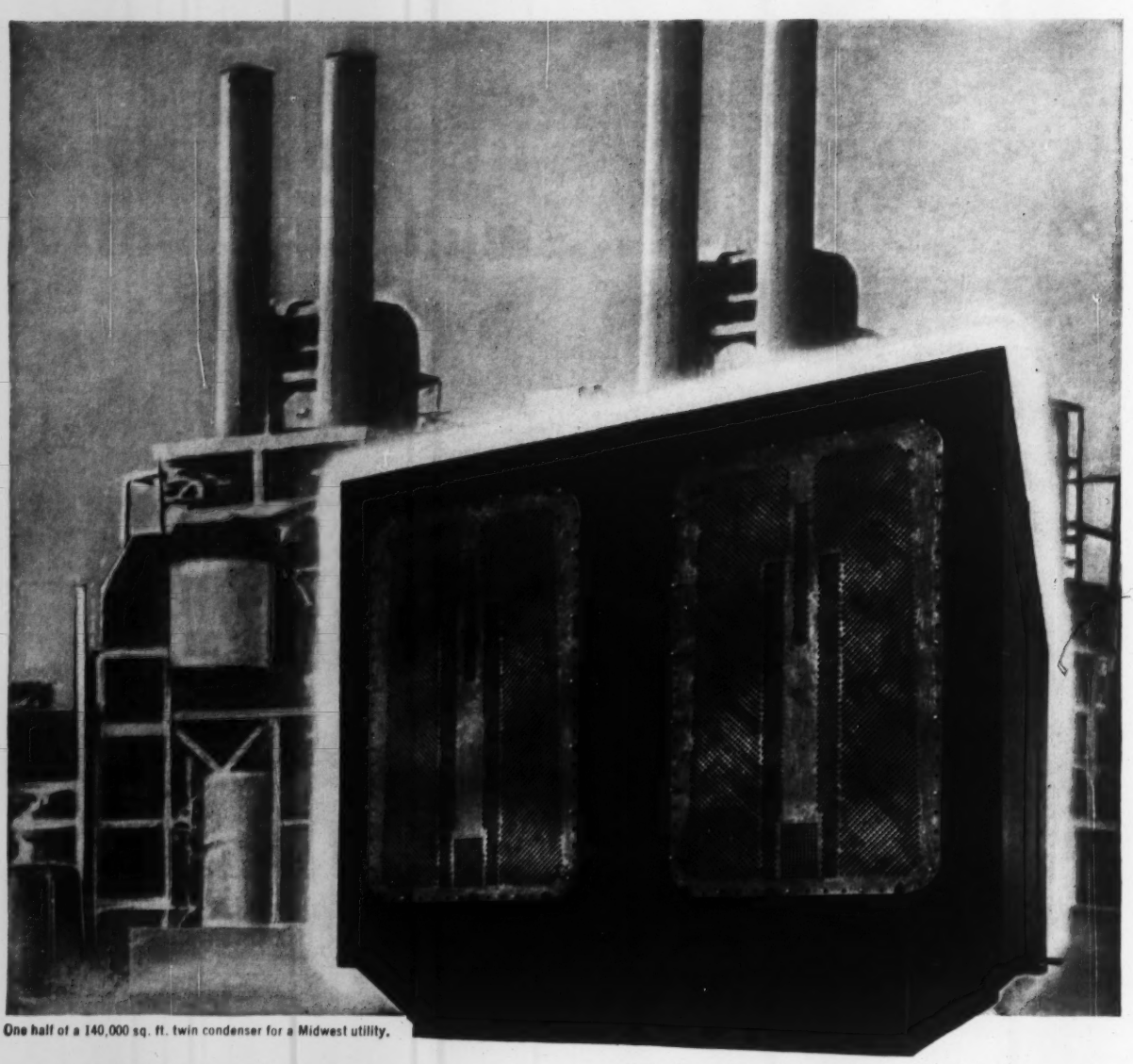
Angle bodies are available with body sections rotatable in 90° increments for piping convenience.

YOURS FOR THE ASKING—

Complete information and specifications are contained in Bulletin No. 9400. Write for your copy today.

ANNIN *Control* **VALVES**

THE ANNIN COMPANY
DIVISION OF THE ANNIN CORPORATION
6570 Telegraph Road, Los Angeles 22, California



One half of a 140,000 sq. ft. twin condenser for a Midwest utility.

C. H. WHEELER Principles of Steam Condenser Design Win Approval of Large Utilities

To help modern power plants conserve every BTU of boiler fuel C. H. Wheeler is working constantly to design and build more efficient steam condensers. Here are just a few of the more important features in C. H. Wheeler Dual Bank Condensers that are recognized by large utilities:

- *Deaeration . . . 0.01 cc per liter is attainable.*
- *"Zero" condensate temperature depression.*
- *Purity of condensate.*
- *Additional steam lanes shorten path and resistance to steam travel.*
- *Lower pressure drop and higher vacuum.*
- *Specifically designed for larger, more efficient electric generating stations.*
- *Adaptable to any station layout and designed to minimize field erection problems.*

C. H. Wheeler representatives are located in principal cities. Let us present a proposal for the most modern Steam Condenser, Pumps and Auxiliaries for your electric generating plants of tomorrow.

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C. H. WHEELER MANUFACTURING CO., 19th & LEHIGH, PHILADELPHIA 32, PA.

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C.H. Wheeler OF PHILADELPHIA

flattening a wrinkle or blasting an invader . . .

LINEAR SILICONE "O" RINGS
MAINTAIN A PERFECT OIL SEAL
under high heat and pressure . . .

The workaday steam iron and the guided operational missile have a common need: Both require seals which withstand *extremes in temperature and pressure.*

In these and many more applications beyond the ordinary thermal range, LINEAR SILICONE "O" RINGS provide the answer. The product of Linear pioneer research, these specially compounded "O" Rings retain flexibility at temperatures as low as —130° F. Yet they also maintain dimensional stability . . . resist compression set at temperatures as high as 500° F.!

Moreover, resistance to moisture, oxidation and mechanical shock make LINEAR SILICONE "O" RINGS an excellent choice in many other modern sealing problems. They are precision molded to your exact specifications. Get the full facts now!

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LINEAR, Inc., STATE ROAD & LEVICK ST., PHILA. 35, PA

RIGHT, in every case

CHAPMAN STEEL VALVES

Check them off, one by one. They're all important to you, a user of valves . . . steel valves. You want close tolerances; tight and positive seats; smooth, dependable, operation without jamming, chattering or excessive wear. Even with long service under the most severe conditions you want to cut your maintenance costs to a new rock bottom low.

Name your metal. You can have Chapman Steel Valves in standard alloys for normal requirements . . . or special alloys for extra service conditions. And for *your* benefit, all of these alloys are poured in Chapman's own foundries under rigid technical supervision.

Chapman superior steel valves — gates, globes, checks — are available for all pressure and temperature ranges. You can order them with bolted, welded or pressure seal body and bonnet joints and with flanged or welding ends. They all equal or exceed ASA and API standards in every range.

Why not write now for our complete descriptive catalog No. 20.

THE
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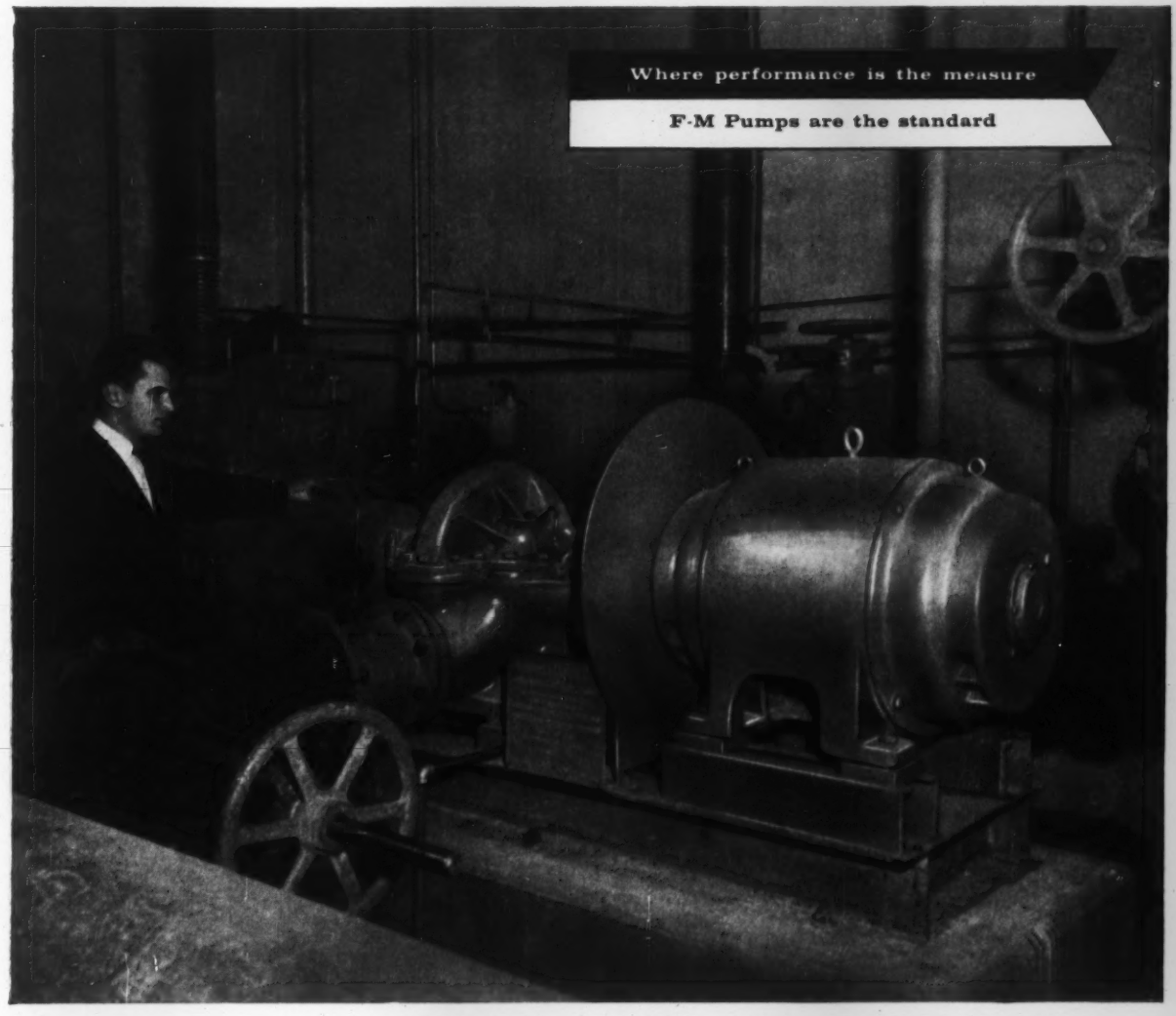


Fairbanks-Morse 6" dual-driven fire pump in jet engine testing laboratory.

Standby against 3500 degrees!

Full power testing of Navy jet engines creates exhaust heat up to 3500° F. a few feet from explosive fuel—a constant fire hazard when in the confines of the testing laboratory.

To insure positive protection against fire losses, Thompson Products Gas Turbine Laboratory, Perry, Ohio, has installed a sprinkling system with a Fairbanks-Morse 6" dual-driven fire pump—capable of pumping 1500 gallons per minute. The installation is so dependable, so positive that prompt approval was given by the authorities having jurisdiction.

Don't gamble with the heart of your fire-prevention equipment; insist on F-M pumps with F-M power. See your F-M Field Engineer for expert assistance, or write Fairbanks, Morse & Co., Department ME-3, 600 South Michigan Avenue, Chicago 5, Illinois.

FAIRBANKS-MORSE
a name worth remembering when you want the BEST

PUMPS • SCALES • DIESEL LOCOMOTIVES AND ENGINES • ELECTRICAL MACHINERY • RAIL CARS • HOME WATER SERVICE EQUIPMENT • MOWERS • MAGNETOS

compare with the standard

...in high speed steels the standard's REX

Ever since grandad's day, Crucible's REX® high speed steel has been *the standard by which all other high speed steels are compared.* And now the quality and uniformity of REX are even *better*, thanks to improved manufacturing techniques at Crucible.

Don't take our word for it. Prove for yourself how REX leads in structure, uniformity, response to heat treatment, and fine tool performance.

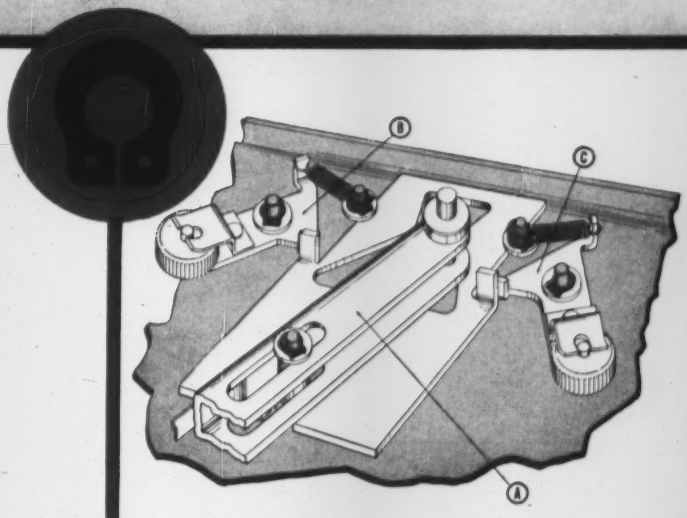
Ask for REX at your nearby Crucible warehouse — or order it through prompt mill shipments. And, for a list of available data on all Crucible special purpose steels, write now for a free copy of the "Crucible Publication Catalog". *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Waldes Truarc grip rings used on die-cast studs eliminate threading, tapping, other costly machining

Mark Simpson Manufacturing Co., Long Island City, N. Y., uses Waldes Truarc series 5555 Grip Rings to secure parts to studs of the zinc die-cast base of its "Masco 500" portable tape recorder.
The rings—which need no grooves—replace nuts, screws, cotter pins and other types of fastening devices which require threading, tapping, drilling and other expensive machining operations. Because a single cracked or broken stud would render the entire cast base useless—and with it, all assembly completed to that point—the rings also eliminate extremely costly rejects.



Pivot Assembly of shift lever (A) is secured by a single Waldes Truarc Grip Ring and washer. Because the washer must be installed over the shift level in a sliding fit, critical tolerances would have to be maintained if a screw or cotter pin were used. The Truarc Grip Ring eliminates that problem: it requires no groove and may be seated over the washer at any point on the stud, automatically compensating for accumulated tolerances in the parts. BRAKE ASSEMBLIES (B and C) use Grip Rings to secure the brake wheel and spring subassemblies. Here again problems of critical tolerances are avoided and expensive rejects eliminated.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

More than 30 engineering-minded factory representatives and 700 field men are available to you on call. Send us your blueprints today... let our Truarc engineers help you solve design, assembly and production problems... without obligation.

For precision internal grooving and undercutting... Waldes Truarc Grooving Tool!

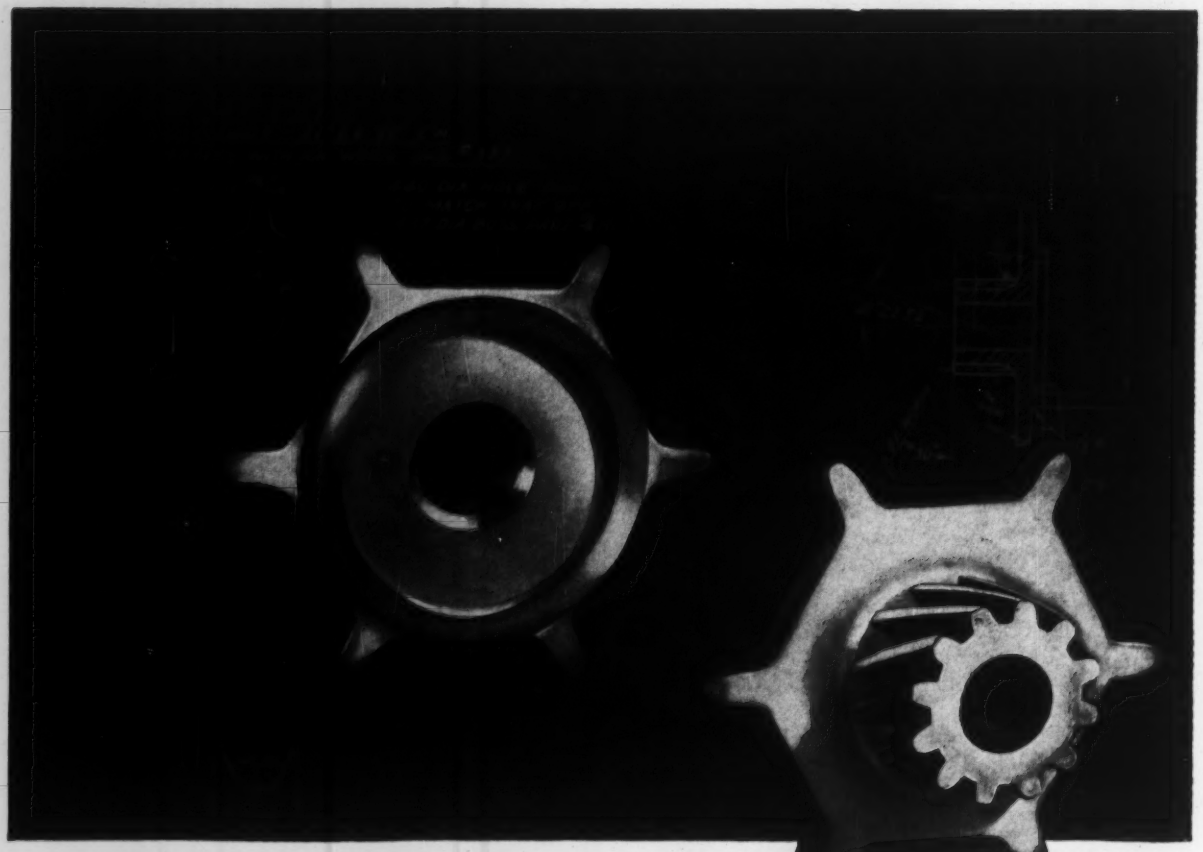
WALDES
TRUARC®
RETAINING RINGS
WALDES KOHINOOR, INC.
47-16 AUSTEL PLACE, L. I. C. 1, N. Y.

Waldes Kohinoor, Inc., 47-16 Austel Place, L. I. C. 1, N.Y.
Please send the new supplement No. 1 which brings Truarc Catalog RR 9-52 up to date.
(Please print)

Name .....
Title .....
Company .....
Business Address .....
City ..... *Zone* ..... *State* .....

ME 039

WALDES TRUARC Retaining Rings, Grooving Tools, Pliers, Applicators and Dispensers are protected by one or more of the following U. S. Patents: 2,382,948; 2,411,426; 2,411,761; 2,416,852; 2,420,921; 2,428,341; 2,439,785; 2,441,846; 2,455,165; 2,483,379; 2,483,380; 2,483,383; 2,487,802; 2,487,803; 2,491,306; 2,491,310; 2,509,081; 2,544,631; 2,546,616; 2,547,263; 2,558,704; 2,574,034; 2,577,319; 2,595,787, and other U. S. Patents pending. Equal patent protection established in foreign countries.



Another Parker-Engineered Die Casting

MACHINED PRECISION at DIE-CASTING COST!

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Produced complete in one operation . . . to extremely close tolerances . . . this helical gear part is yet another example of the way Parker-engineered die castings can save you money by eliminating costly tooling-up and machining operations on component parts. Combine this inherent cost advantage with exceptionally smooth as-cast finish, high density and good tensiles and you can see why Parker Die Castings—in zinc or aluminum—open up wide new possibilities to the design engineer.

Parker has been a leader in die-casting for 50 years—an old hand with new ideas. Take advantage of this skill. Just call the nearest Parker sales engineer or write the factory direct.

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PARKER

high pressure ALUMINUM and ZINC die castings POWDERED METAL PARTS

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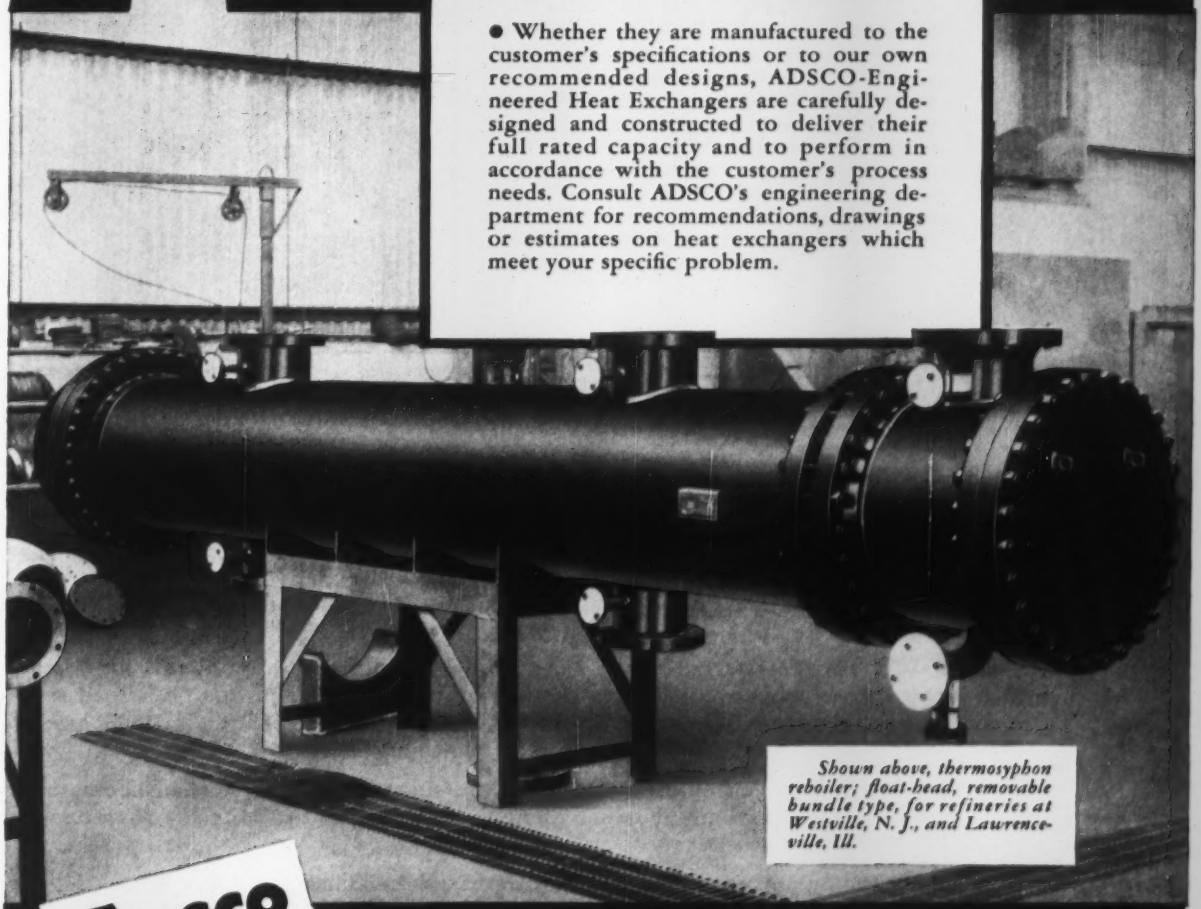
ENGINEERED HEAT EXCHANGERS

● Whether they are manufactured to the customer's specifications or to our own recommended designs, ADSCO-Engineered Heat Exchangers are carefully designed and constructed to deliver their full rated capacity and to perform in accordance with the customer's process needs. Consult ADSCO's engineering department for recommendations, drawings or estimates on heat exchangers which meet your specific problem.



Shown above, thermosyphon reboiler; float-head, removable bundle type, for refineries at Westville, N. J., and Lawrenceville, Ill.

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ADSCO INDUSTRIES, INC.

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IN 20 MINUTES

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GAS TURBINES

BROWN BOVERI large output gas turbines go into operation at full load *in 20 minutes or less* from a cold start. That's why they are so ideal for peak load service. Operating experience with Brown Boveri gas turbines shows a 25% *proven* efficiency . . . a new standard for performance and economy.

First costs of gas turbine power plants are substantially lower than comparable conventional power plants. Further economies are realized in long life, low operating costs and low maintenance.

Discover how Brown Boveri large output gas turbines can solve your peak or base load problems. Write for the facts, today.

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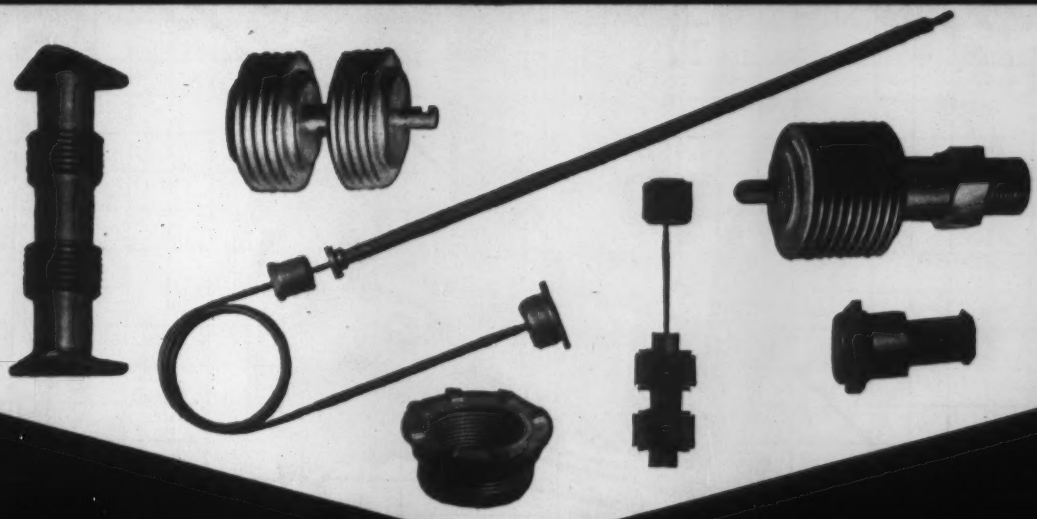
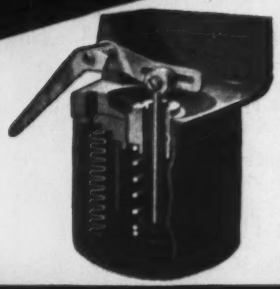
HOW TO SAVE TIME AND MONEY ON COMPLETE BELLOWS ASSEMBLIES



No matter why or how the bellows principle enters into an assembly, Fulton Sylphon can assemble the right bellows and related accessories or mountings into a complete device that meets your specifications. In doing this Fulton Sylphon offers important design help, specialized skill in joining bellows with other members, and modern production facilities for on-time deliveries.



BELLOWS FOR INSTRUMENT ASSEMBLIES

are available with diameters, lengths, strokes, spring rates, metals and charges to provide a wide range of movements in high or low pressure systems. In all applications the exclusive Sylphon® bellows assures continuing accuracy and safety of operation. For one thing, cold-working production methods give it maximum resiliency for withstanding repeated cycling. In addition, its *seamless* design and the availability of multiple plies enable the Sylphon bellows to better resist pressure and other conditions.

Send for Bellows Catalog EK—1400

Mr. Controls

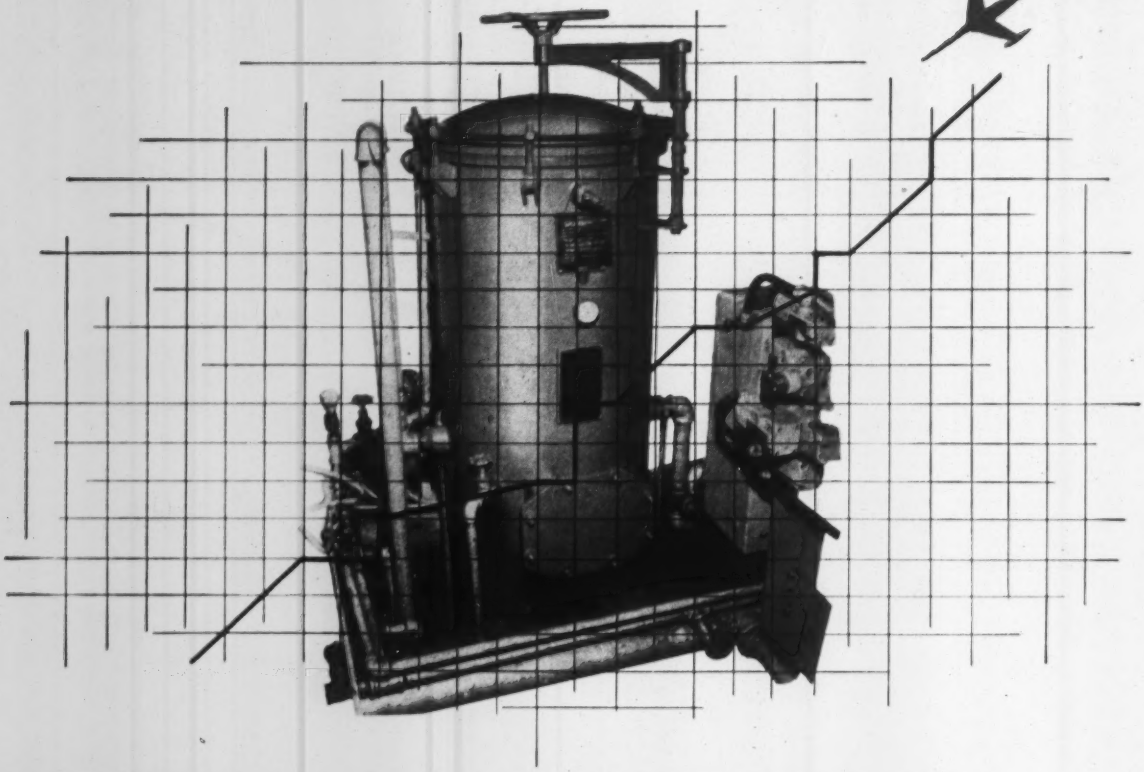
Robertshaw-Fulton

CONTROLS COMPANY

FULTON SYLPHON DIVISION, Knoxville 1, Tenn.

FULTON · SYLPHON · BELLOWS · HEADQUARTERS · U.S.A.

Hoffman engineered systems get **results:**



HOFFMAN COOLANT FILTRATION SYSTEM

achieves great savings on honing operations at **BENDIX AVIATION!**

Engineers at Bendix Aviation Corporation, Pacific Division, found that oil used in the honing of aircraft hydraulic cylindrical barrels quickly became saturated with small particles. Efficiency was being pushed down by scratches in the bores of the barrels, by the need for continual trueing of honing stones and by production loss and re-working. At the same time, costs were being pushed up by the replacement of honing stones and oil solution—100 gallons a month—as well as by re-work expense.

Hoffman engineers recommended a central pressure filter system to treat the coolant from seven hones, with a combined flow rate of 25 g.p.m. The tiny particles are continuously filtered out by an inexpensive filter medium which is easy to replace. As a result, Bendix Aviation is making substantial savings on honing oil and stones . . . production has been increased . . . and far fewer pieces have to be re-worked.

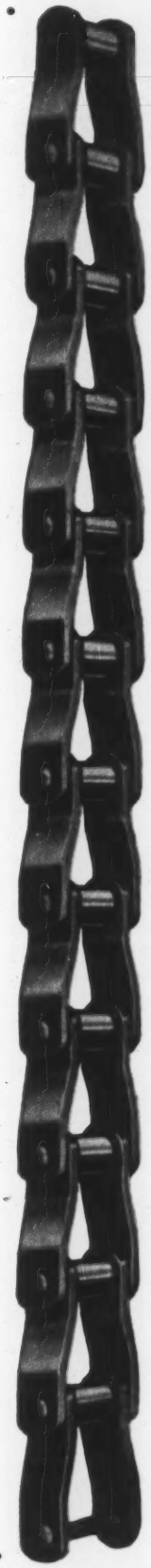
On the basis of 250 working days per year, the installation had paid for itself within 16 months!

Hoffman "custom" filtration equipment has added efficiency and cut expenses in many types of industry. Wouldn't it be well worth your while to look into the impressive savings a Hoffman filtration system could bring **you?** Write for Case Study No. 7, Bulletin M-129.

INDUSTRIAL FILTRATION DIVISION U. S. HOFFMAN MACHINERY CORPORATION DEPT. ME, 103 FOURTH AVENUE, NEW YORK 3, N.Y.

INDUSTRIAL FILTRATION DIVISION Machine Tool Coolant Clarifiers—Flotation, Mechanical, and Magnetic. Lubricating and Insulating Oil Conditioners, Filters, and Vaporizers. Solvent Recovery Systems—Vacuum Stills and Filters. **ORDNANCE EQUIPMENT DIVISION** Special Pneumatic Conveying Systems. High Efficiency Centrifugal Separators. Stationary and Portable Vacuum Cleaning Equipment. Process Equipment. Pneumatic Systems for Radioactive Materials. **AIR APPLIANCE DIVISION** Multistage Centrifugal Blowers and Exhausters. Pneumatic Conveying Equipment. Industrial Vacuum Cleaning—Portable and Stationary Systems. Continuous Metal Strip Driers. "Smoothflow" Fittings and Tubing.

YOU ARE CORDIALLY INVITED TO VISIT OUR BOOTH, NO. 510, AT THE PLANT MAINTENANCE SHOW



When your power drive considerations involve:

HEAVY LOADS

Rex Chabelco Chains are your economical choice. These are the "work horse" chains...designed and built with extra strength and ruggedness. They have carefully hardened surfaces for *longest* wearing life...inner ductility to resist the heaviest shock loads.

TOUGH OPERATING CONDITIONS

Rex Chabelco Steel Chains operate efficiently under toughest operating conditions. Planned tolerances and "built-in" clearances between working parts enable Chabelco to withstand effects of dust, dirt, heat and abrasion...last longer than any other type of chain.

SLOW TO MODERATE SPEEDS

As a "work horse," Rex Chabelco operates most efficiently in the slow to moderate speed range. Their pitch is longer than chains designed for higher speed service and, within its range, Chabelco assures lowest cost per dollar of h.p. transmitted. They can be used with cast tooth sprockets, an important cost-saving advantage.

choose REX® Chabelco Chains for lowest cost

Within their broad service range, Rex Chabelco Steel Chains are your economical choice for power drive service. Naturally, they are *not* the answer for every drive. Because they are designed for "work horse"...not "race horse"...service, they are not particularly suitable for ultra high speed service. But for heavy loads, slow to moderate speeds, and tough operating conditions, they are by far your best choice. Why not have a CHAIN Belt District Sales Engineer explain why you'll get so much more with Chabelco. Write CHAIN Belt Company, 4765 W. Greenfield Ave., Milwaukee 1, Wis.

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creative opportunities in

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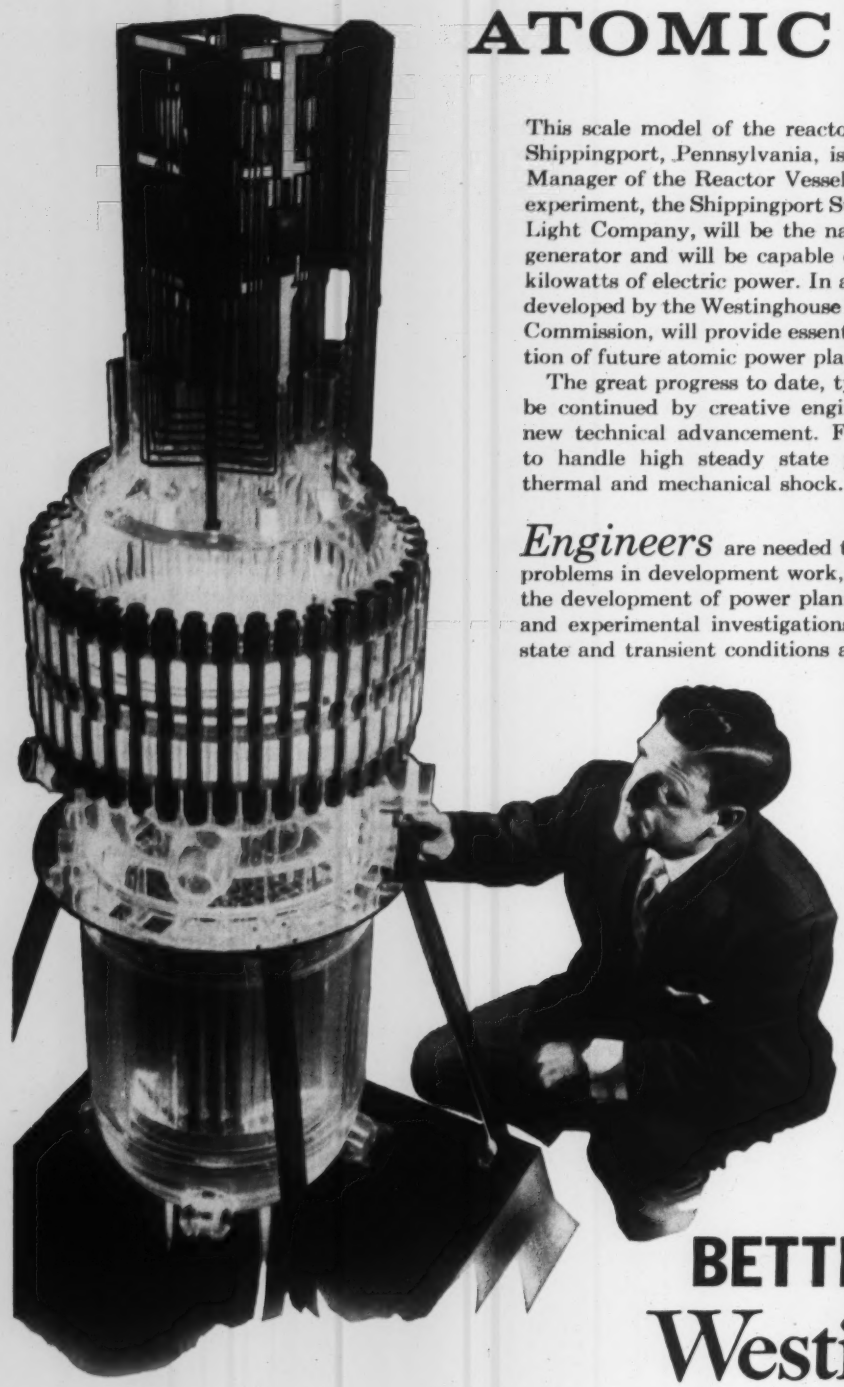

This scale model of the reactor for the atomic power station at Shippingport, Pennsylvania, is being checked by P. A. Halpine, Manager of the Reactor Vessel Design for this project. No small experiment, the Shippingport Station, to be operated by Duquesne Light Company, will be the nation's first full-scale atomic power generator and will be capable of producing a minimum of 60,000 kilowatts of electric power. In addition, this plant, which is being developed by the Westinghouse Bettis Plant for the Atomic Energy Commission, will provide essential data for the design and operation of future atomic power plants.

The great progress to date, typified by the USS *Nautilus*, must be continued by creative engineers who enjoy the challenge of new technical advancement. For instance, ways must be found to handle high steady state pressures accompanied by severe thermal and mechanical shock.

Engineers are needed to solve unusual thermal and stress problems in development work, particularly in reactor design and the development of power plant auxiliaries. Extensive theoretical and experimental investigations into heat transfer under steady state and transient conditions are necessary to determine reactor design parameters. Atomic experience is not a prerequisite.

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If you are interested in working in the expanding field of atomic power, write for the brochure, "Tomorrow's Opportunity Today." Address Mr. A. M. Johnston, Westinghouse Bettis Plant, Dept. A-128, P.O. Box 1468, Pittsburgh 30, Pa.

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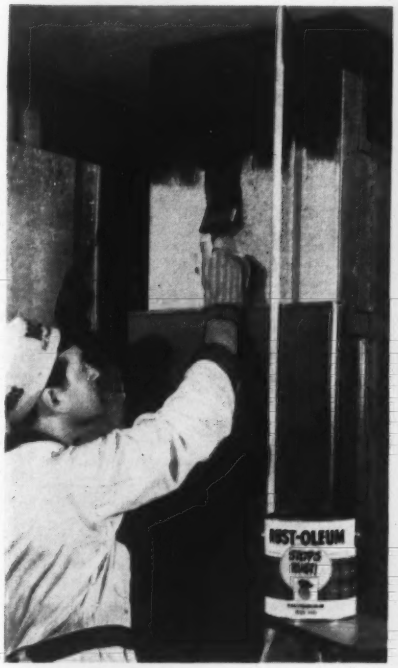

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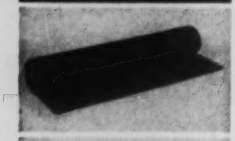

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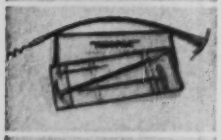

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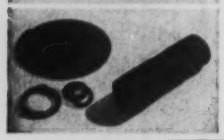

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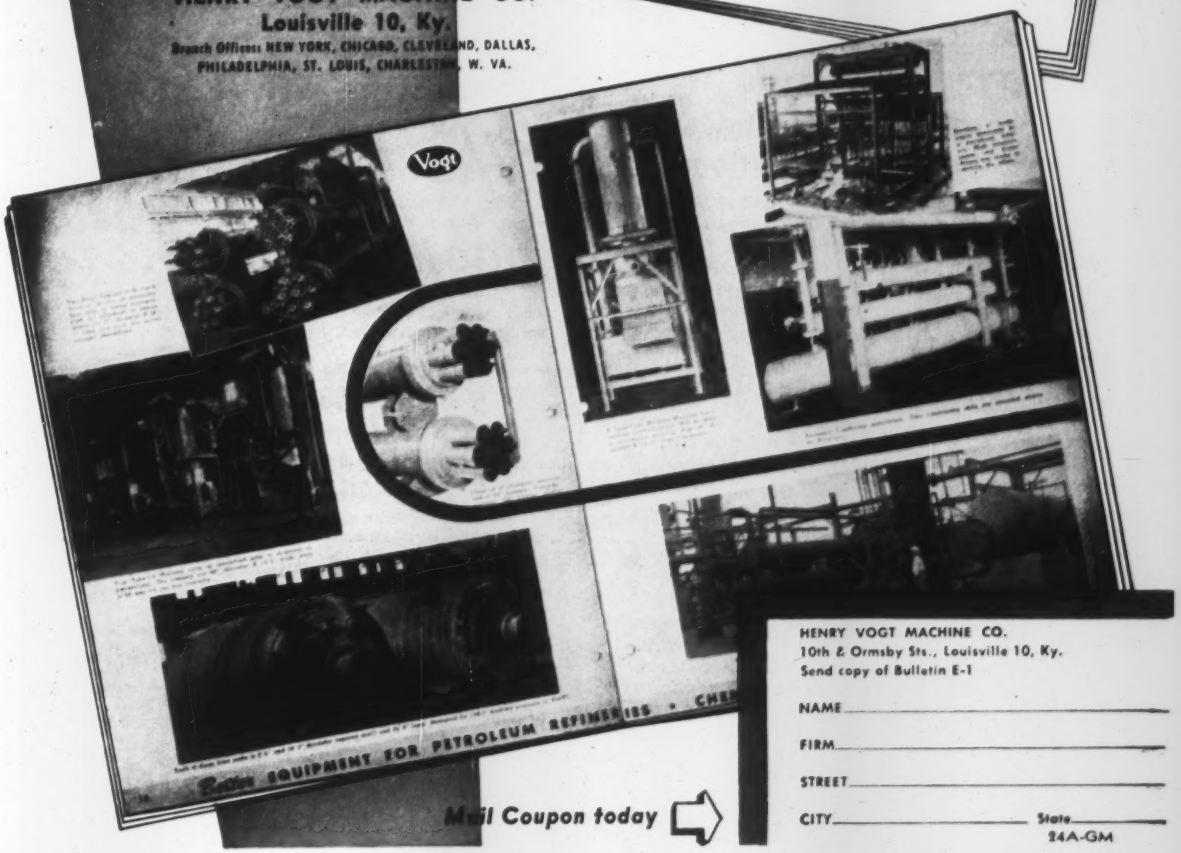

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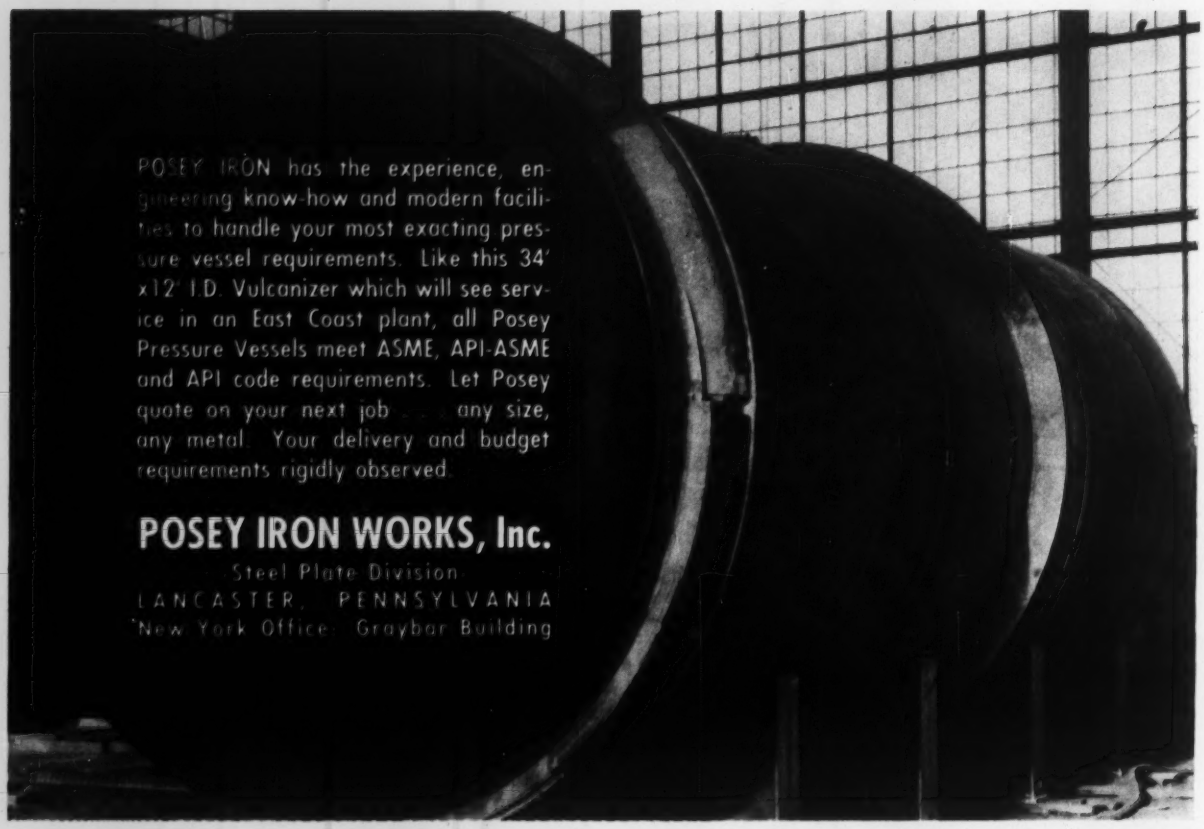
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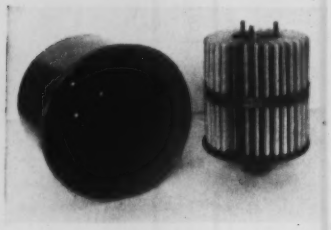

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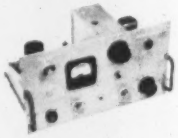
ME-3

TECHNIQUES and DEVELOPMENTS in oscillographic recording

PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

THE measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.



A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100.1; for carrier frequencies up to 5000 cycles.

Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

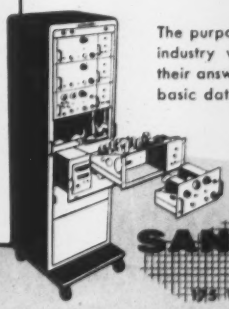
For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."

Technical literature and engineering assistance on specific problems are always available from our engineering department.

FROM **SANBORN**

BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

WHEN considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.



The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.

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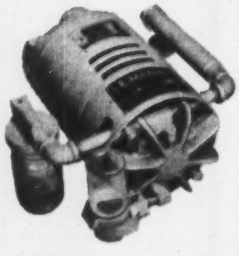

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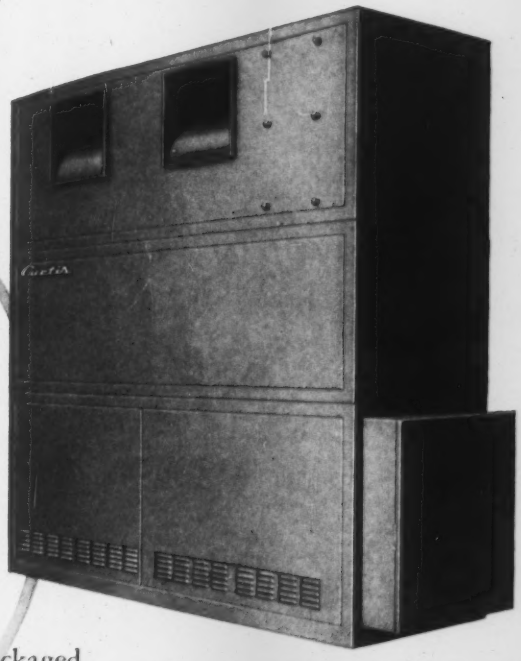

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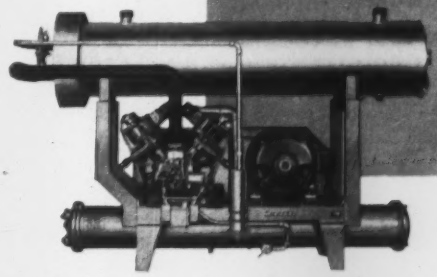

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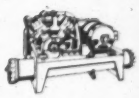

Condensing Units up to 100 tons. F-12 or F-22.

Air Handling Units, Cooling Towers and Evaporative Condensers to match.

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CM-16

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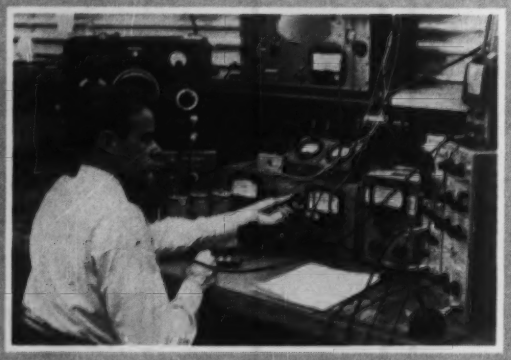

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- Airborne transmitters
- Transistorized video and pulse circuitry
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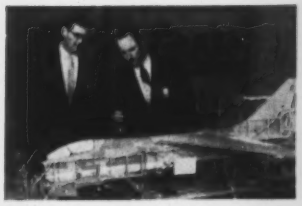
WHY MORE THAN 500 ENGINEERS CALL IT "MY AIRPLANE"

Successful weapons and well-rounded engineers have a common denominator at Chance Vought. It's Vought's "project-group" system, a highly-effective brand of development teamwork that makes each engineer an inside man in the over-all development picture. On Vought's record-breaking Crusader fighter, the system worked like this:

In Vought's project-group system there's advancement opportunity for experienced project men, technical specialists and junior engineers alike. Arrange to visit Chance Vought for a firsthand investigation. Or, for a report on our openings,

write to:
Mr. J. W. Larson
Asst. Chief Engineer
Dept. ME-2

Engineers selected from their original groups for the Crusader project followed their assigned systems and sub-assemblies from preliminary design to flight test. Teamed with engineers from other groups, they lent mutual assistance, worked outside their own specialties, and enlarged their view of the program. At the same time, liaison was maintained with the original groups on methods, research and policy. This way, the Crusader became everyone's aircraft, and everyone learned. That's the value of the project-group system. Linking group with project, it coordinates the state of the art with the practical problems of project work. Joining engineers of one specialty with those of another, it offers each a better compromise and a wider view.



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You pay neither sales tax nor city and state income tax in Dallas. You can use these savings as Dallasites do — on outdoor fun for the family. Lakes, links and ranches are close at hand, and the Gulf's within an easy half-day's drive.

5

IMMEDIATE OPENINGS FOR ENGINEERS

Structures Research Specialist. For research and development assignments on new missiles and fighter aircraft. Requires advanced degree in structural mechanics plus eight years experience in aircraft structural design and analysis.

Senior Structures Loads Engineer. To determine air and ground loads and airframe temperature distributions; analyze aircraft shipboard performance, and determine repeated loading criteria of aircraft components. Requires degree in engineering, applied mathematics or physics and at least three years experience in loads, applied mechanics or mathematics.

Support Equipment Engineer. For a wide range of development assignments including complete airborne photo systems and submarine handling equipment for guided missiles. Engineering degree and at least three years design experience.

Systems Engineer. For design and test of electro-hydraulic and hydro-mechanical servo control systems. Requires engineering degree, or equivalent, plus one to four years related experience.

Senior Engineer for Dynamic Analysis. For flutter analysis on high-speed digital computers, flutter model testing in transonic tunnels and vibration testing of completed aircraft. Requires engineering, mathematics or physics degree and experience in dynamics.

CHANCE VOUGHT AIRCRAFT INCORPORATED

Dallas, Texas

ADVISORY LEVEL POSITION FOR MECHANICAL STANDARDS ENGINEER

The Missile and Ordnance Systems Department of General Electric, prime contractor for the ICBM and IRBM nose cones, now has an excellent position available on its staff for a Mechanical Standards Engineer with proven analytical ability capable of working effectively with different individuals and groups.

Position Responsibilities: Develop departmental mechanical components standards; participate in company, industry, professional society, and government standards work. Advise all elements of the department regarding mechanical engineering standards.

Position Requirements: At least five years' experience in mechanical engineering standards at professional level, or at least eight years' mechanical engineering design and manufacturing engineering experience, at least two years of which were concerned with machine parts and components rather than with systems and products.

Salary and benefits are liberal, and the facilities and equipment are excellent. We hold prime contracts of a long-term nature with all of the armed services. Our Manager of Engineering Administration will review your resume and, if your qualifications are appropriate, invite you to visit our Philadelphia location at our expense for a personal interview. If you prefer, you need not reveal your present employer.

Please send resume in confidence to:
Mr. John Watt, Technical Recruiting, Room 570-3

MISSILE & ORDNANCE SYSTEMS DEPARTMENT

GENERAL ELECTRIC

3198 CHESTNUT STREET, PHILADELPHIA 4, PA.

HOW TO BE THE HAPPIEST CREATIVE ENGINEER IN CALIFORNIA

Engineers (E.E., M.E., Mfg., Sales) can have the kinds of jobs that creative men dream about. Top salaries and benefits. Suburban locations in Fullerton, Newport Beach, Richmond, or Palo Alto.

Write Beckman Instruments, Inc., 2999 W. 6th Street Los Angeles 5, California. Ask for Career File #55-3.

RESEARCH ENGINEERS

Challenging positions are available in research and development for men with B.S. to Ph.D. degrees in Physics or Mechanical Engineering and experience or interest in the fields of rocket propulsion, ballistics, and ordnance.

We offer you an opportunity to use your initiative and creative ability in an atmosphere conducive to accomplishment. These positions afford association with some of the leading engineers in this field.

Excellent employee benefits including tuition free graduate study. Please send resume to:

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ARMOUR RESEARCH FOUNDATION
of
Illinois Institute of Technology
10 West 35th Street
Chicago, Illinois

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assignment: *Creative Engineering*

to design the "Forward Look" of tomorrow

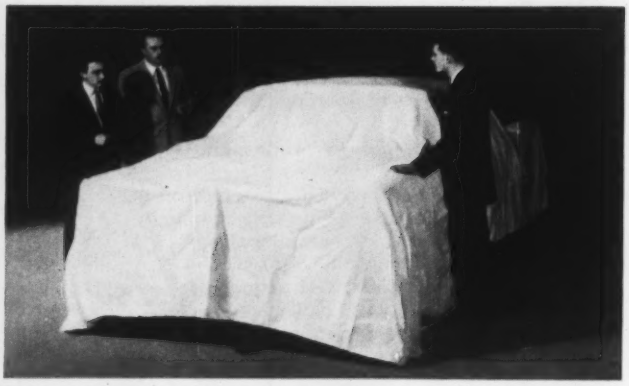
At Chrysler Corporation, we seek a certain kind of engineer: one who wants his assignments *creative.*

That's because the famous "Forward Look" must go right on looking ahead. It's not enough, for us, that *today's* Chrysler Corporation cars are out in front in performance, value and beauty. We have to make sure we keep that position *in the years to come.*

If you're a creative man who refuses to rest on his oars, maybe you can help us keep from resting on ours.

At Chrysler, you'll find your assignments creative. You'll find flexibility and freedom. The chance to make your own decisions. Good pay. Fellow employees and supervisors easy to work with. Very good advancement opportunities, including extra rewards for ambition and accomplishment. The chance to increase your knowledge at the famed Chrysler Institute of Engineering. And the opportunity to profit by working with people who are authorities in the field.

The man to write is Mr. L. C. Bettega, Chrysler Corporation, Engineering Division, P.O. Box 1118, Detroit 31, Michigan. You'll get complete information from him, about your future working with our future.



What will tomorrow's "Forward Look" be like? You may help to shape it. Join the engineering team whose imagination will do so much to make Chrysler Corporation cars and your opportunities even more outstanding.

CHRYSLER Corporation
ENGINEERING Division
P.O. BOX 1118, DETROIT 31, MICHIGAN

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NEW opportunities at MOTOROLA

YOUR CHOICE OF 3 LOCATIONS

New Motorola research laboratories are expanding, creating outstanding career advantages—your opportunity to get in on the ground floor of a swiftly expanding company. You'll enjoy working in these modern laboratories . . . with liberal employee benefits, including an attractive profit sharing plan. Salary levels are open and commensurate with ability.

POSITIONS AVAILABLE IN: two-way communications • missile electronics • radio & TV (color) • weapons systems • computer application & design • transistor research & production • microwave systems • servo-mechanisms • physical chemistry • metallurgical eng. • field eng. • electronic sales eng. • drafting, design, & layout • aerophysics • radar & military electronics

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Outdoor, relaxed living the year-round, with lots of room to grow (on the job and off) in this land of sunshine.

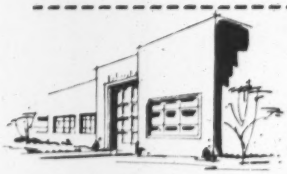
RESEARCH LABORATORY
write to: **Mr. R. Coulter, Dept. E, 3102 N. 56th St., Phoenix, Ariz.**

SEMI-CONDUCTOR LABORATORY
write to: **Mr. V. Sorenson, Dept. E, 5005 E. McDowell Rd., Phoenix, Ariz.**

RIVERSIDE, CALIFORNIA

Planned communities, modern shopping centers, advanced schools, fine buys in homes. There's room to grow and more fun in Riverside.

write to: **Mr. C. Koziol, Dept. E, Box 2072, Riverside, Calif.**



CHICAGO, ILLINOIS

Live a relaxed midwest life in one of the beautiful suburbs, yet have all the "big city" advantages—cultural, social, and educational.

write to: **Mr. L. B. Wrenn, Dept. E, 4501 Augusta Blvd., Chicago, Ill.**

MOTOROLA

ENGINEERS!

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Telemetering
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Miniature Electric Motors
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Bendix-Pacific offers you this broad cross section of absorbing tasks.

Now, in Southern California, you will find excellent positions open for electronic, hydraulic and mechanical engineers at all levels. At Bendix-Pacific the diversity of work never traps you in the monotony of a one-product job.

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Pacific Division, Bendix Aviation Corp.
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I am interested in this engineering field ____.
I am a graduate engineer with ____ degree.
I am not a graduate engineer but have ____ years experience.

Name ____
Address ____
City ____
Zone ____ State ____

Compressor Design Engineer

SALARY TO $12,000

This major company needs an analytical engineer, with heavy experience in the aero-dynamics and mechanics of rotary compressor design, to aid further expansion in the lightweight gas turbine power plant field.

This specialist will establish design criteria and procedures, conduct experimental and analytical studies and provide technical guidance. He will also make recommendations to management in regard to facilities, budgets and programs, and, in general, extend compressor design practices.

If you qualify, please send resume in confidence to:

BOX CA-6113,
Care of
"Mechanical Engineering"

CHALLENGING OPPORTUNITIES IN RESEARCH AND DEVELOPMENT

for

FLUID MECHANICS ENGINEERS

Engineers of advanced standing will find challenging work at the Garfield Thomas Water Tunnel of the Ordnance Research Laboratory located at The Pennsylvania State University. This laboratory is engaged in basic and applied research in the field of underwater propulsion and related subjects, including cavitation, hydroelasticity, and hydrodynamic control of submerged bodies. The existing openings offer opportunities for combining research and development work in these fields with various academic activities.

MECHANICAL ENGINEERS

Mechanical engineers with research ability and experience in missile development.

University faculty appointments

Opportunities for graduate study.

Liberal vacation allowances.

Security benefit programs.

Send Resume to:
ARNOLD ADDISON, *Personnel Director*
THE PENNSYLVANIA STATE UNIVERSITY
ORDNANCE RESEARCH LABORATORY
University Park Pennsylvania

AN EXCELLENT OPPORTUNITY IN DESIGN, CONSTRUCTION AND LIAISON

MECHANICAL OR CHEMICAL ENGINEERS FOR DESIGN ENGINEERING AND CONSTRUCTION OF PETROLEUM RESEARCH PILOT PLANTS

Engineers are needed to act as project engineers in a growing company in the field of process research.

Work consists of translating process requirements into completed operating pilot plants and includes mechanical design, proper application of equipment, instrumentation, cost estimation, scheduling, materials procurement, field supervision of construction, initial operating shake-down, and new equipment development.

Experience in any of the above fields is desired with the ability to direct the work of others and to deal with a professional research staff. Excellent opportunities for advancement. Salary commensurate with training and experience.

Give full details of education, experience, desired salary, availability date and references. All inquiries will be considered promptly and held confidential.

ESSO RESEARCH AND ENGINEERING COMPANY
(Chief Technical Subsidiary—Standard Oil Company (New Jersey))
Esso Research Center
Employee Relations—C
P. O. Box 51 **Linden, N. J.**

Flight Test Facility . . . Bedford, Mass.

Missiles are TOPS and we're TOPS in Missiles!

Included among the most important efforts in this country's plans for defense are the design and development of missiles. History making events, such as the first interception of an aircraft by a guided missile (Navy's LARK) were made possible by Raytheon's engineering staff. Raytheon is the only electronic company in the country with TWO prime missile contracts (Navy and Army). The Missile Systems Division is composed of a dynamic active organization of over 3400 employees including more than 500 engineers. Our contract commitments are increasing—we need additional engineers to grow with us.

You start at an excellent rate of pay with periodic increases based on ability and performance. Raytheon pays the major cost of graduate study at Harvard, M.I.T., Boston University or Northeastern. Our staff attends meetings and seminars at Company expense.

Raytheon's tradition of achievements in the forefront of electronic research and development—the opportunity to advance rapidly as an individual—the combination of exceptional living conditions (suburban or rural), proximity to Boston (cultural, educational, medical, recreation & research center)—a healthy and varied climate—engineer management—all these have attracted a growing number of able engineers to us.

If you are interested in guided missile systems and have experience in these fields:

Mechanical Design	**Heat Design**
Hydraulics	**Electro-mechanical packaging**
Aircraft Structures	**Infra-Red**

Come in, telephone or send brief resume to:

G. P. O'NEIL

RAYTHEON *MISSILE SYSTEMS DIVISION*

BEDFORD, MASS.

STAFF ENGINEERS

Mechanical or Industrial

MATERIAL HANDLING ENGINEER

IE or ME with two to five years' warehousing and internal material handling experience in process industry. Applicant should exhibit creative abilities in the design and development of new equipment and methods. Work involves surveying, analyzing and recommending improvements—receiving, storage, in process handling and shipping activites. Recommend economics of handling and storage space, increasing of capacity, reduction of inventory and handling hazards, improvement of working conditions as well as expediting material control and delivery.

POWER ENGINEER

ME with eight to ten years' experience in application of engineering principles to specific plant power requirements. Requirements include extensive experience in design and operation of power, refrigeration, ventilating and air condition equipment and application of power costs, recommending replacement of equipment and selection of new equipment, advise plants on operation and maintenance of power equipment, and in developing design recommendation.

The above positions are with a central engineering staff servicing a multi-plant operation.

For further information, send resumé and salary history to:

L. H. Snyder
Employment Manager
ATLAS POWDER COMPANY
Wilmington 99, Delaware

DESIGNERS

WHERE do you start training for promotion from your first day on the job?

For the answer, turn to page 163

Mechanical Engineers are putting Electrons to Work at RCA

...and now, mechanical engineers can help create RCA's advanced airborne weapons systems

Mechanical engineers are particularly essential in this field, for desired performance characteristics are running into barriers of mechanical limitations. The men who can qualify will create the muscles and sinew that change electrical impulses into more powerful weapons forces...such as airborne fire control systems or airborne communications. It will take real engineering ingenuity to develop reliable mechanical equipment of the lightest weight to fit in the smallest space and function in extremes of environmental shock, vibration, cooling, humidity and altitude.

Today, RCA has openings of interest for mechanical engineers with experience in:

Vibration and stress analysis
Electronic thermal design
Precision mechanism design
Electronic and hydraulic servo application
Printed circuitry and transistor packaging
Electronic equipment packaging
Aircraft installation and structures design
Environmental testing

Positions for both Junior and Senior Engineers . . . excellent opportunities for professional advancement . . . liberal benefits . . . Tuition Refund Plan for advanced education.

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Engineering Personnel, Dept. Z-11C
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Bldg. 10-1, Camden 2, N.J.

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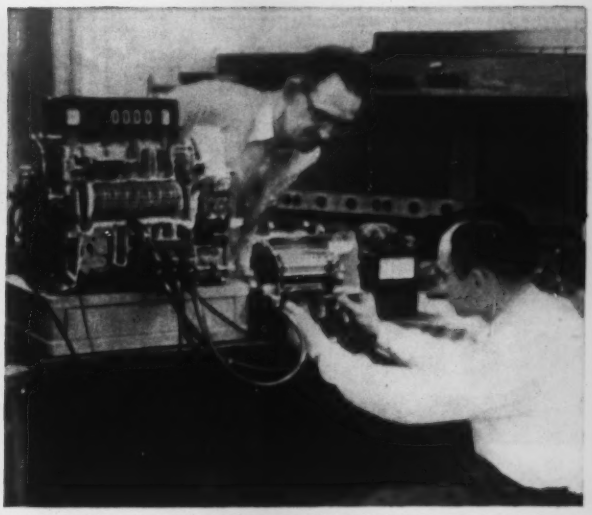
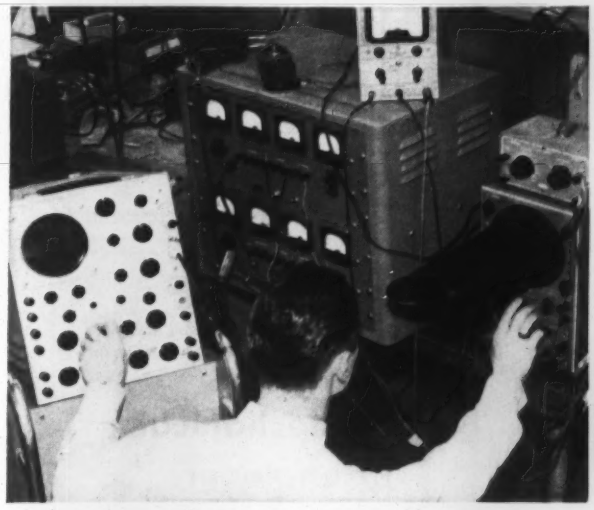
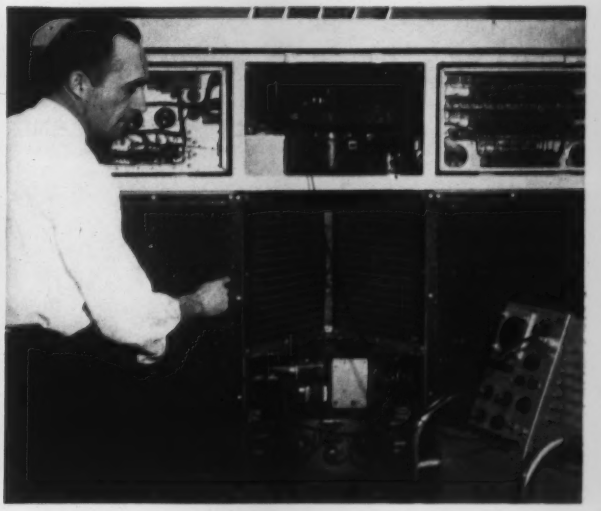
MECHANICAL ENGINEERS are using their skills in the design and development of new mechanisms required for business machines and for those mechanical products which are associated with electronic data processing equipment.



ELECTRO-MECHANICAL ENGINEERS are constantly faced with the problems of capturing information from the various input devices and converting this information into a usable form for subsequent use in data-handling equipment.



ELECTRONIC ENGINEERS enjoy an unparalleled freedom in the development of new types of circuitry and components which are necessary to maintain leadership in the competitive field of record-keeping automation.



COMPUTER ENGINEERS backed by the company's computer research since 1938 are developing an economical, flexible digital computer to meet the requirements of all record-keeping applications.

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AT ONE OF THE WORLD'S MOST SUCCESSFUL CORPORATIONS

If you are looking for a challenging opportunity with an established company which has tripled its sales in ten years—one that offers excellent starting salaries as well as permanent positions . . .

Act at once! Send resumé of your education and experience to Employment Department, Technical Procurement Sec. M, The National Cash Register Company, Dayton 9, Ohio.

NCR

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THE APPLIED RESEARCH LABORATORY of the UNITED STATES STEEL CORPORATION

MONROEVILLE, PENNSYLVANIA

has challenging career opportunities for

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Fields of activity include heat transfer, vibration, materials handling, process machinery, mechanisms and stress analysis. Work includes experimental and analytical studies, development of original designs, model building and testing, liaison with plant engineering, operating and maintenance groups and cooperative work with outside agencies and equipment manufacturers. Salary will be based upon education and experience, with opportunities for advancement in research specialization or technical administration. Ph.D., M.S., and B.S. levels are required.

If this type of work appeals to you, think of these advantages:

Modern laboratory facilities with a campus atmosphere

Proximity to the city of Pittsburgh provides choice of urban or rural living

The opportunity to obtain advanced degrees at one of Pittsburgh's leading universities

The employment stability afforded by the world's largest steel producer

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Applied Research Laboratory, United States Steel Corporation

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. . . able to tackle new assignments

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Communications equipment—ultra-small and lightweight receivers and transmitters for airborne, portable and field use—is being designed and developed at Light Military Department.

We are particularly interested in men with experience in the packaging of transistor circuits and electronic equipment of subminiaturization.

Our excellent facilities for environmental and vibration testing make this position very attractive.

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SYLVANIA'S

Electronic Defense Laboratory
(Located in the San Francisco Bay Region)

NEEDS

mechanical engineers

Preferably with experience in military and electronic equipment.

Sylvania offers the finest facilities and equipment available. We also provide financial support for advanced education, as well as a liberal insurance, pension and medical program.

Our laboratory is located five miles from Palo Alto in the San Francisco Bay area, close to excellent schools and universities, unexcelled living conditions, ideal climate and ample housing.

RELOCATION EXPENSES PAID.

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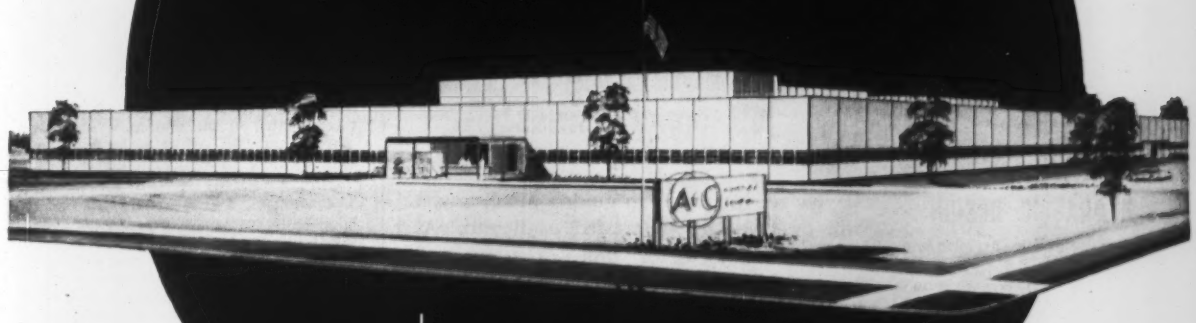
ENGINEERS

AC OFFERS YOU SECURITY

G M's long-standing policy of decentralization creates unlimited opportunities for qualified Electrical, Mechanical Engineers and Engineering Technicians.



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AVIONICS – MISSILE GUIDANCE – JET ENGINE FUEL CONTROLS – COMPUTERS – COMMUNICATION EQUIPMENT – CIVIL DEFENSE AVIATION – AUTOMOTIVE ELECTRONIC PRODUCTS all offer you personally, opportunities that demand investigation. To arrange personal, confidential interview in your territory, write today to

Mr. Cecil E. Sundeen,
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AC'S new, modern 225,000 square feet, glass-masonry, aluminum plant (being built in suburban Milwaukee) is another step in GM's Electronics Division's Permanent, Progressive Program.

For a confidential opinion as to how YOU can fit BEST in our Challenging Program write to us today.

AC THE ELECTRONICS DIVISION
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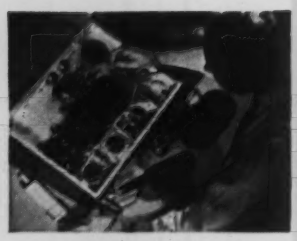
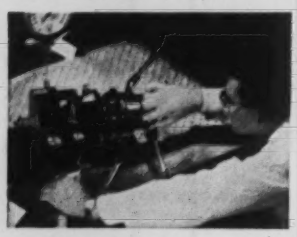
Milwaukee 2, Wisconsin • Flint 2, Michigan



TEST EQUIPMENT

The Test Equipment Engineer is engaged primarily in the design of specialized missile check-out equipment. As missiles push the state of the art, test equipment must exceed the missiles in precision and reliability. Automatic programing, go-no-go evaluation, and automatic data processing add up to automation in missile testing.

This engineer is evaluating his design of a precision power supply—one of the building blocks that will be system engineered into a family of versatile matched missile and sub-system test equipment. Engineers work as individuals.



HYDRAULIC DESIGN

Excellent opportunities are available for the engineer to observe the performance of his design. Here, under the watchful eyes of its designer, a hydraulic power unit is undergoing adjustment and setting prior to severe testing at simulated high altitude conditions.

Many components, which a few months ago seemed almost impossible to design, are now being tested under the severe conditions required to qualify them for flight operation—and passing with flying colors.

STEERING INTELLIGENCE

Two Steering Intelligence Engineers discuss space allotment in a new guidance component. This close association of engineers with the "flying" equipment is typical of the Steering Intelligence Section. Engineers in this section are primarily and directly concerned with refining the guidance equipment to steer the missile with greater accuracy, at greater ranges and with simpler and more reliable electronic equipment and, consistently, with minimizing the cost. Work is actively in progress in every principal field from microwave equipment to inertial and instruments.

Bendix

PRIME CONTRACTOR FOR TALOS MISSILE

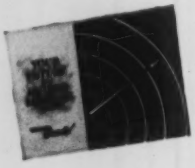
Offers more interesting and challenging job opportunities!

If you are interested in guided missiles, you will be especially interested in Bendix. As prime contractor for the important and successful Talos Missile, the job opportunities here cover the widest possible scope, and the opportunities for advancement are practically unlimited.

Here is a compact, hard-hitting organization backed by all the resources of the nation-wide Bendix Aviation Corporation—an organization dedicated to the design and production of the finest in guided missiles.

If you can accept a challenge, want an opportunity to grow with a leader in its field, and can accept the responsibility that goes with opportunity, send for the thirty-six-page book "Your Future in Guided Missiles". It gives the complete, detailed story of the function of the various engineering groups and the many job opportunities available for you.

Just fill out the coupon. It may help you plan a successful future in the guided missile field.



Bendix Products Division—Missiles
4091., Bendix Drive, South Bend, Indiana

Gentlemen: I would like more information concerning opportunities in guided missiles. Please send me the booklet "Your Future In Guided Missiles".

NAME _____

ADDRESS _____

CITY _____ STATE _____

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Excellent opportunity for mechanical, electrical, or civil engineer with approximately ten years' construction, maintenance and design experience preferred. Plan and supervise projects at Midwestern plant of major nonferrous metal smelting company. Write promptly giving all details including experience, education, salary expected.

P. O. Box 1106, Church Street Station, New York 8, New York

CAN YOU THINK CREATIVELY?

Would you like to be a free-lance inventor with a regular salary?

Dream your own dreams of invention, then develop and perfect them with the assistance of a 120-men Engineering Division and a staff of Patent Attorneys.

No time card, no written reports, just the responsibility of creating and developing ideas. All this plus extra bonuses for patents, patent applications and promising ideas.

A leading electrical appliance manufacturer located in the middle west needs new ideas and is willing to provide just such a setting for a young engineer with creative ability.

The man being sought preferably is under 40 and has several patents or patent applications to his credit. If you can qualify for such a position and are interested, please submit a brief resume.

Address CA-6125, % "Mechanical Engineering."

Small Company
BIG OPPORTUNITY

We are looking for two exceptional, qualified ENGINEERS to fill important administrative engineering positions.

Qualifications must include a B.S. in Engineering and proven ability in the supervision of engineering personnel. Ability to coordinate work efforts with the efforts of other groups, departments, companies, and government agencies is essential.

Experience in electro-mechanical, office equipment or photographic fields would be helpful.

Imagination and inventiveness is required, plus the capacity for personal growth in a pioneering organization located in upper New York State.

Please submit resume and salary requirements to:

Box 6131,
care of "Mechanical Engineering."

Mechanical Engineers

You Ought to Know This Important Fact:

Your Engineering Skill can be used now on

IMPORTANT PROJECTS IN AIRCRAFT NUCLEAR PROPULSION

It's true—you can join this rapidly expanding organization without nuclear experience. What's more, the skill and training you now have can be used immediately and will be the foundation for a new, exceptionally rewarding career because . . . here you'll receive the nucleonics training you need.

How?—through a full-tuition refund plan for university courses leading to an M.S. in nuclear engineering, or any other graduate degree, through in-plant training courses that give you the most thorough grounding in aircraft nuclear propulsion available today. On the job, you'll apply your skills to nuclear power systems under the guidance of top men in the field.

If you have sound engineering training and from one to five years' experience, you may qualify for assignments that make full use of your talents, like these:

Thermodynamics, stress and weight analysis, shield design, remote handling, heat transfer, cycle analysis, turbo-jet applications, power plant components, reactor design and structure, airframe and structures, fluid heat-flow transfer.

- *Comprehensive employee benefit program*
- *High starting salary*
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Advances are fast being made into the product stage. You owe it to yourself to find out how your ability can be used in a field that will shape the future of aviation.

Openings in the West and Mid-West

Send replies in confidence, stating salary requirements to:

BOX CA-6104, CARE OF "MECHANICAL ENGINEERING."

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...if YOU are interested in MORE than "just a job"

DU PONT is interested in YOU!

Please send complete resume, including details of education and experience, to:
Mr. T. J. Donovan
Engineering Department

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To a designer who seriously wants to grow in his field,
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Progress and promotion are commensurate with ability and performance.

Comprehensive and varied training programs to develop both technical and administrative abilities.

Promotion-from-within. This, plus continuous Company growth, assures both excellent advancement opportunities and stability.

Progressive benefit programs provide immediate and long-term security — majority company-paid.

APPLY NOW to fill one of these immediate openings for:

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PROCESS EQUIPMENT DESIGNERS
MECHANICAL DESIGNERS
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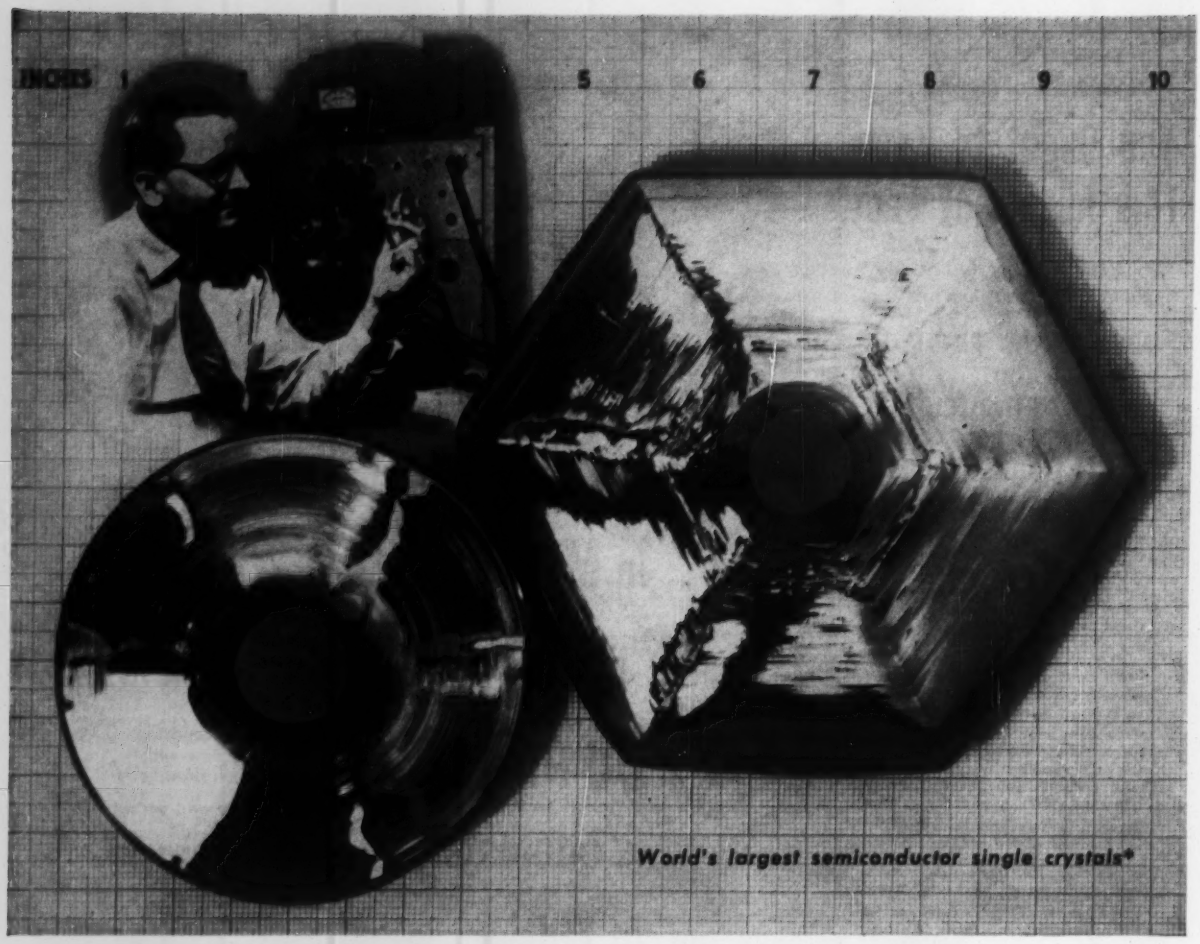

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L. A. Riedinger (center) Design Specialist, J. E. Jean (left) Stress Group Engineer, and J. A. Johnson, head of the Structures Engineering Department, discuss structural effects of high thermal gradients in thin wall pressure vessels.

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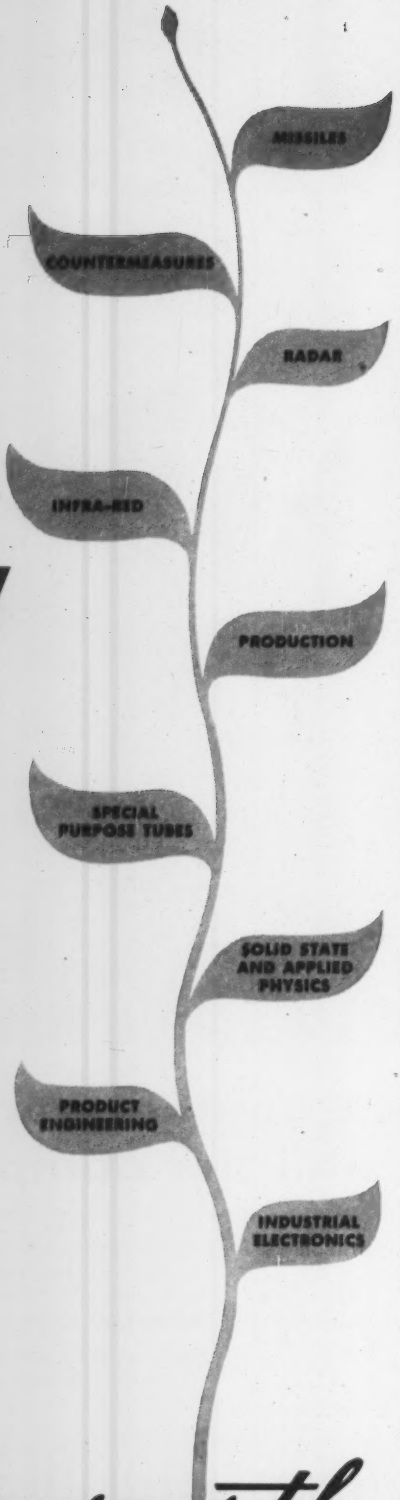

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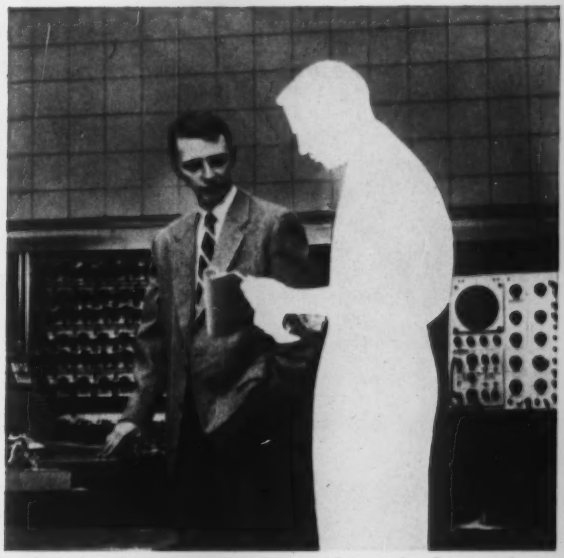

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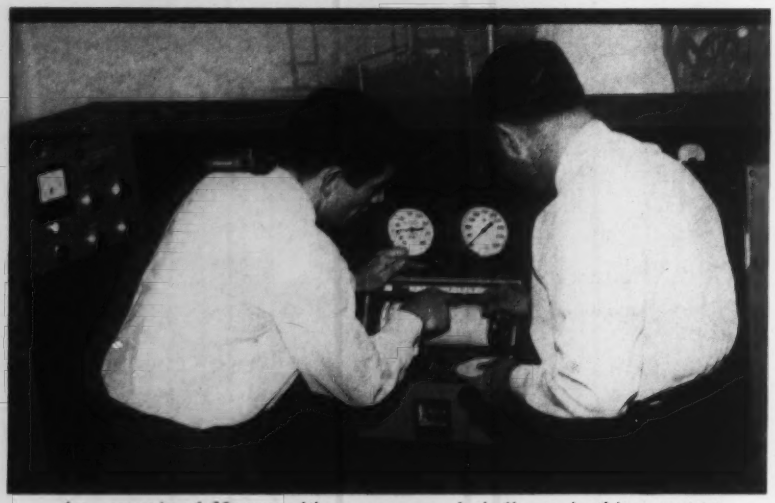

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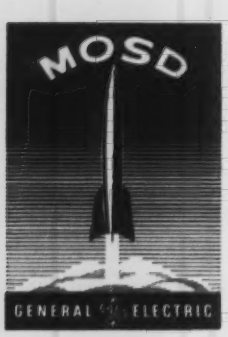

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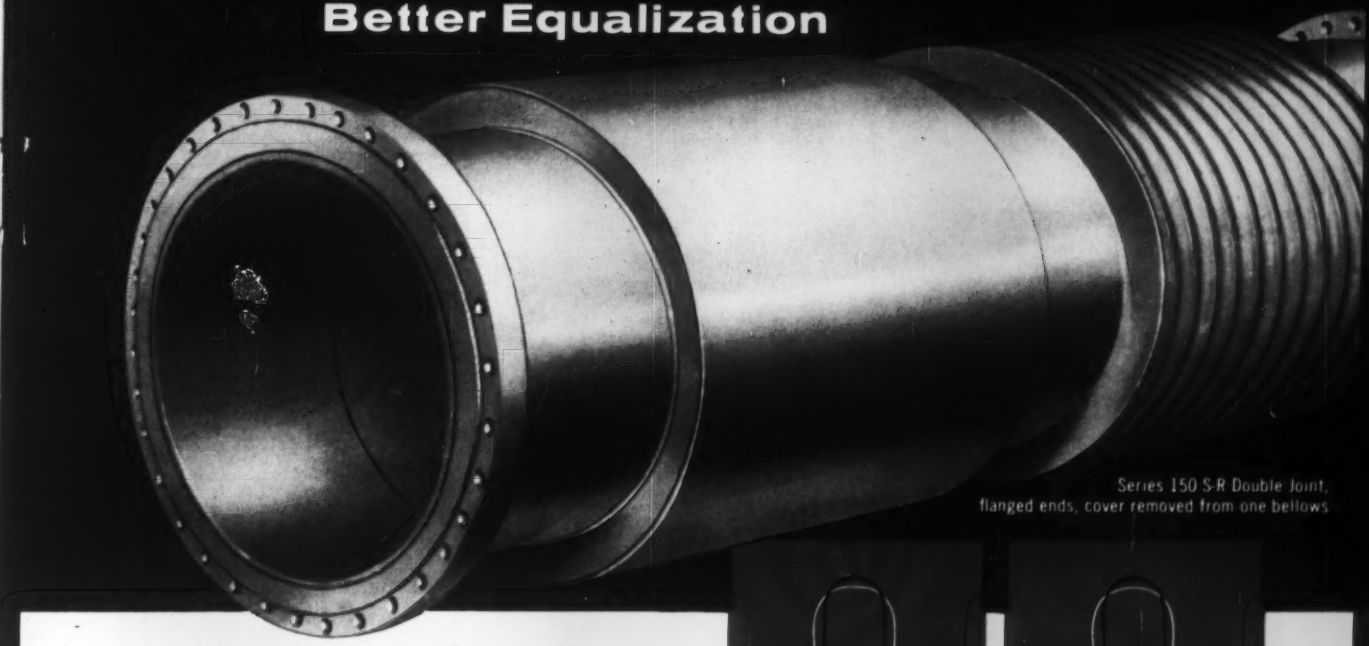

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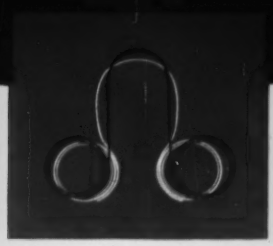

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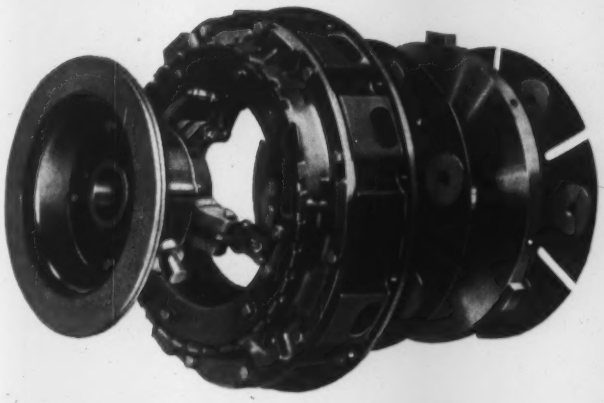

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what's on your mind?

If it has to do with ballistic missiles, you know you're an ME who's both wanted and needed. But the big question: Where will you be happiest? We're convinced the answer is Firestone, where ideas are king, and where a creative climate encourages idea development.

At Firestone, men with leadership on their minds have pioneered in research, development and manufacture for 57 years. Currently, they're carrying forward the vital "Corporal" program for the Army. Perhaps more exciting, our facilities in both Los Angeles and Monterey are blazing new trails toward history-making goals.

Right now, we need more ME's with minds headed in these directions:

Structures Airframe
Dynamics
Stress Analysis
Materials & Process
Hydraulics
Propulsion System Design

A man at Firestone has a mind to discuss a happy future for you. Write him for a meeting of the minds.

Firestone

GUIDED MISSILE DIVISION

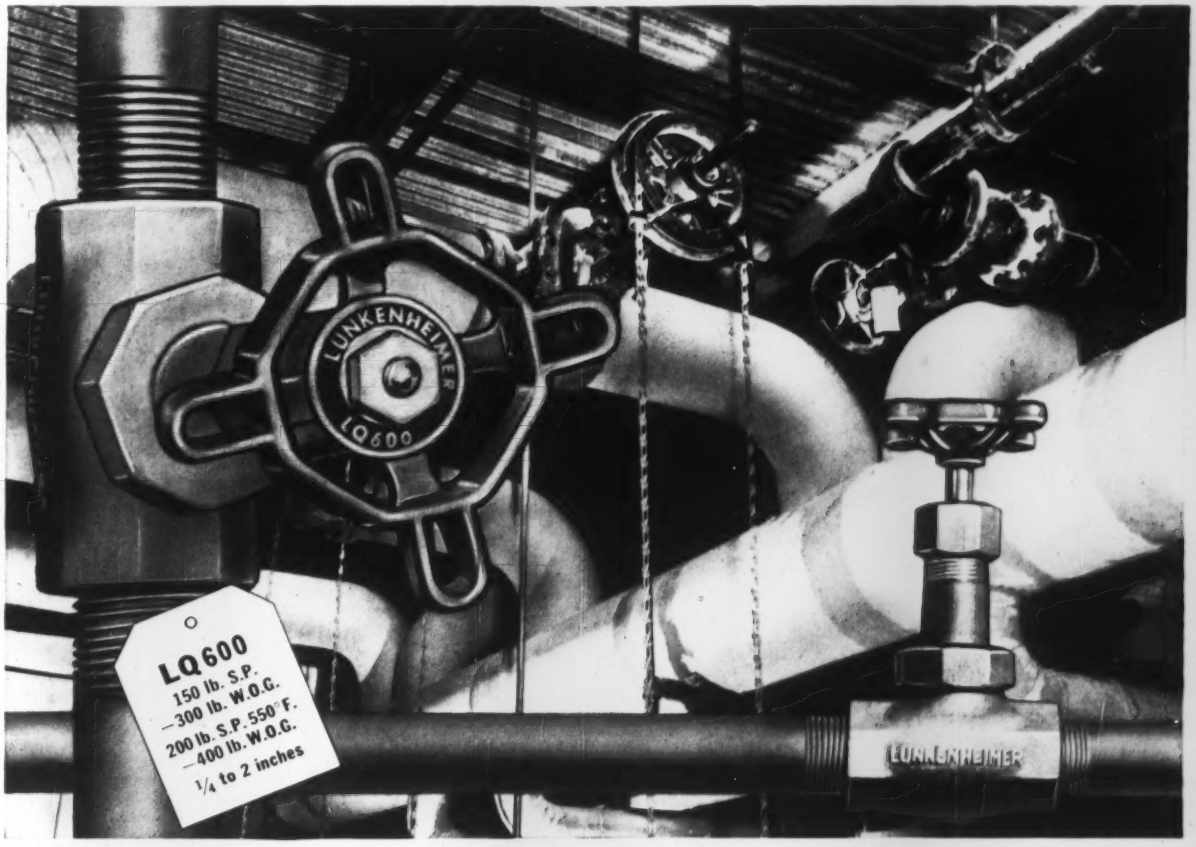
RESEARCH • DEVELOPMENT • MANUFACTURE

"Find your Future at Firestone"– Los Angeles • Monterey

WRITE: SCIENTIFIC STAFF DIRECTOR, LOS ANGELES 54, CALIF

Today, maintenance often costs more than the equipment itself!

You Can't Afford Less than the Best



What's happened to maintenance costs? That's a question you hear time and again in management-maintenance meetings these days. Costs are up sky-high and labor rates are still rising. The minute you touch a wrench to a valve, its cost can more than double! You can't do anything about the labor costs, but you can cut maintenance expense to rock-bottom by installing the one bronze globe valve that's handwheel-and-bonnet above all others . . . the LQ600, by Lunkenheimer. Thousands of these valves have served without maintenance for five years and more — many on the toughest throttling services industry can offer. The secret? Exclusive Brinalloy* seats and discs — harder than 500 Brinell Stainless! Insist on LQ600 Valves to help solve your number-one problem . . . sky-high maintenance expense. The Lunkenheimer Co., Box 360, Cincinnati 14, Ohio.

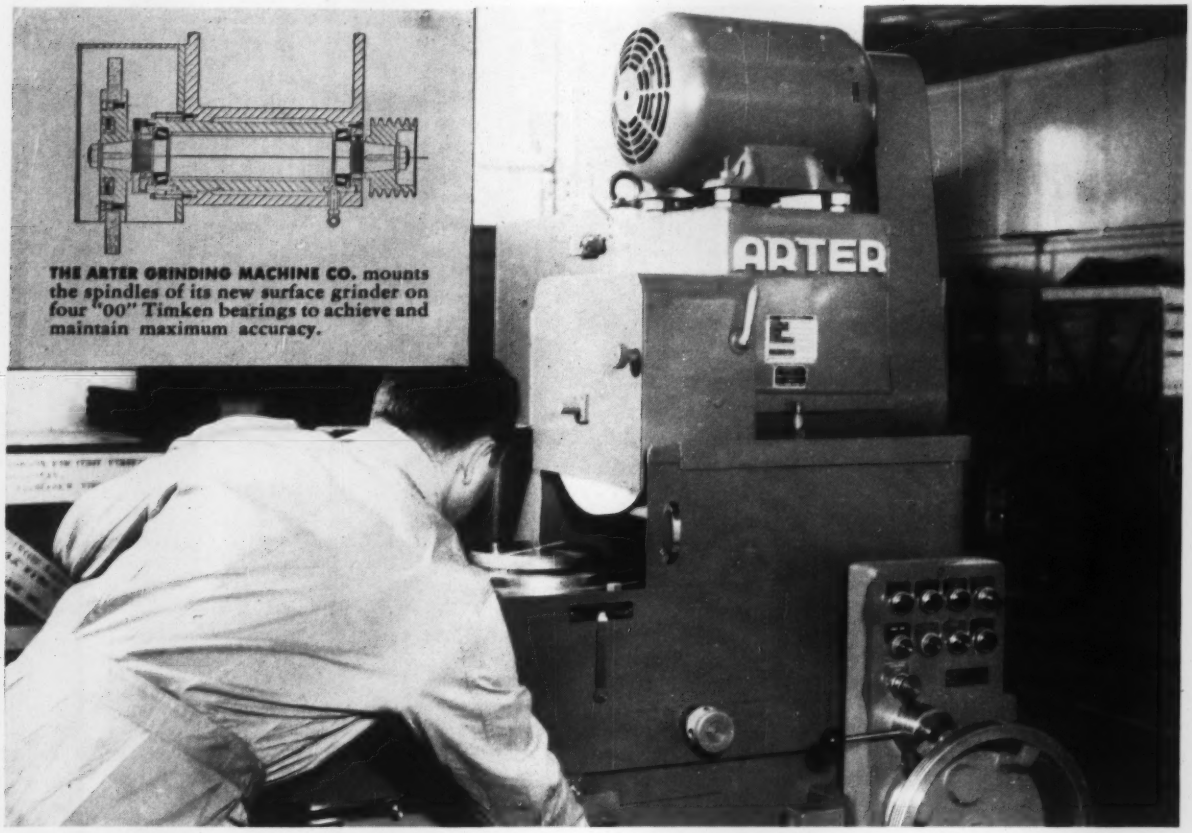
The cost of a LUNKENHEIMER VALVE
Gets smaller... and smaller... *and smaller...*
with each passing year of dependable service

**Patented alloy — T. M. Reg.*

L-157-19

LUNKENHEIMER QUALITY

LUNKENHEIMER®
THE ONE *Great* NAME IN VALVES



THE ARTER GRINDING MACHINE CO. mounts the spindles of its new surface grinder on four "00" Timken bearings to achieve and maintain maximum accuracy.

New precision grinder costs less to make, gives smoother spindle operation with TIMKEN® bearings

TO get the smooth spindle operation required for the extreme precision of their new surface grinder, The Arter Grinding Machine Company mounted the work spindle and the wheel spindle on four "00" Timken® tapered roller bearings. The extremely low run-out tolerances of Timken "00" bearings—75 millionths of an inch—make possible the closest machining tolerances ever achieved. And by using two Timken precision bearings on the spindle, Arter got greater capacity in less space—cut manufacturing costs ⅓ over earlier spindles used.

Timken "00" precision bearings not only deliver highest precision, but like all Timken bearings, they take both radial and thrust loads in any combination. And full line contact between Timken bearing rollers and races gives them extra load-carrying capacity. Shafts are held rigid — accuracy is maintained — gear life increased. Timken bearings run smoothly because they practically eliminate friction. They're designed by geometric law to have true rolling motion and precision manufactured to live up to their design. Normally last the life of a machine they're in.

The Timken Company developed "00" bearings to meet the demands of today's new precision machine tools. To produce these bearings, the Timken Company perfected measuring devices of unprecedented precision and developed new manufacturing techniques. The "00" bearing has achieved twice the precision of any previous Timken bearing.

Whatever machines you buy or build make sure your bearings are the best. Look for the trade-mark "Timken" on every bearing and be sure of maximum life, dependability, and minimum maintenance. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD